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Cover Picture: Greenland children collecting peridots from a crumbling picritic intrusion above the village of Igdlorssuit, Ubekendt Ejland, West Greenland. *Photo: H. I. Drever*

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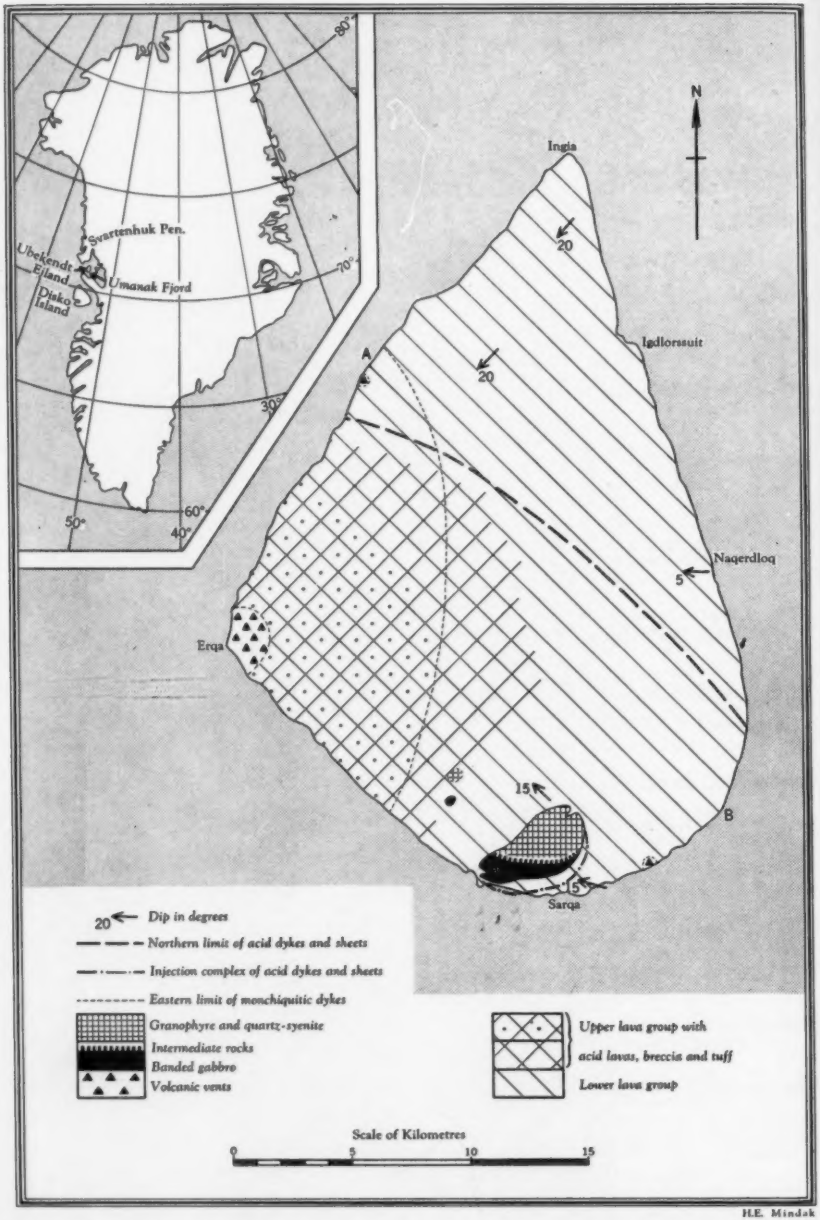

Fig. 1. Geological sketchmap of Ubekendt Ejland, West Greenland (location shown on inset). A. B — southern limit on northwest and east coast respectively of picritic intrusions. Occurrence of pyroclastic rocks in the upper group of lavas is indicated by dots.

GEOLOGICAL RESULTS OF FOUR EXPEDITIONS TO UBEKENDT EJLAND, WEST GREENLAND

Harald I. Drever*

Introduction

THE rocks in many arctic localities are particularly well exposed, and the evidence they provide of the principles of their derivation is correspondingly well displayed. Ubekendt Ejland, in the Umanak Fjord region of West Greenland (Fig. 1), is one such locality. The geology of this island is so rich in variety and so fundamentally significant that it can be predicted, without exaggeration, that it will become a classic geological locality. The principal purpose of this paper is to help to substantiate this view by recording the main geological discoveries of four expeditions (1938, 1939, 1950, and 1957) and to demonstrate in a broad conspectus how these discoveries have disclosed some lines of petrological enquiry that not only have proved to be rewarding (in terms of published and partly completed research) but also seem likely to be very fruitful in the future.

A preliminary outline of the geology of this island has already been published (Drever and Game, 1948) and it is one of the objects of the present paper to amplify and amend this earlier work. Abundance of magnesia and forsteritic olivine (Game, 1942) in the lower group of lavas, and in many of the minor intrusions that cut them, was regarded as the problem most likely to justify detailed investigation (Drever, 1956). Petrographical information obtained during this work has led to the examination (or re-examination) of many olivine-rich rocks in the Hebridean area of Scotland and in others parts of the world (Drever and Johnston, 1957, 1958, 1959). It can now be recorded that almost the maximum possible information has been assembled about the natural occurrence and variations in olivine-rich minor intrusions from the two areas — Ubekendt Ejland and the Scottish Hebrides — where they attain their most varied and prolific development. The research so far has disclosed a number of anomalies in these rocks that are not explicable in terms of the classical theory (Bowen, 1928) of crystal accumulation (cf. Drever, 1952). One of the anomalies is the fact that many of these rocks are abnormally rich in lime.

But it is not only in the development of magnesia- and lime-rich intrusions and lavas that Ubekendt Ejland is of special importance geologically. Nowhere else in the whole volcanic province, stretching from Disko

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Island in the south to the Svartenhuk Peninsula in the north, is there a central intrusive complex as in the south of Ubekendt Ejland, or a suite of dykes, lavas, and pyroclastic rocks, such as those on its west coast. It is quite possible that the results of a detailed investigation of both these areas may rival in importance what has already been contributed by the rocks in the east and north.

A brief report of the 1950 expedition was published in *Arctic* (Vol. 3, No. 3) as Northern News, but no account of the writer's work on Ubekendt Ejland in 1957 has yet been published. This was mainly a detailed investigation of the eastern cliffs from a base camp on the outskirts of the village of Igdlorssuit, from which several Greenlanders were recruited. For transport an outboard-powered dingy was used. This expedition received generous financial support from the Carnegie Trust for the Universities of Scotland. It also owes much to the help of Danish residents in Greenland and the kayakers of Igdlorssuit (Drever, 1958).

Geological structure and the lava succession

The key to the structure of Ubekendt Ejland is a flat median valley bordered by mountains to the north and south (Fig. 6). It can be readily discerned on air photographs in the Danish Geodetic Institute that this median valley has been to a large extent structurally determined. It is a flat syncline with a western pitch that is responsible for the occurrence toward the west of the uppermost rocks in the succession. The lowermost rocks are at Ingia, the most northerly point.

Apart from some slumping near the coastal cliffs, which has changed the inclination of the lavas particularly in the area immediately south of Igdlorssuit, no evidence has been observed of any major faulting or block displacements. Regional dips are commonly between 15 and 20 degrees but in some places are appreciably steeper. The total thickness of the lower group of lavas can be estimated, on a simple trigonometrical basis, along a line normal to the strike from Ingia to a point on the coast northeast of Erqa. This thickness amounts to at least 5 kilometres. The characteristic lavas of the group are olivine-rich, picritic types, which are developed on a vastly greater scale than anywhere else in the world, with the possible exception of the unknown Hawaiian succession below sea-level. If to the lower group on Ubekendt Ejland the upper is added, the thickness of the visible volcanic pile is one of the greatest ever recorded and yet neither the base nor the top of the succession is exposed. Noe-Nygaard (1942) has estimated that the total thickness of the lava pile in Svartenhuk Peninsula, to the north of Ubekendt Ejland, is 10 kilometres. The extent to which picritic flows are there represented is unknown.

The lavas of the lower group represent flood eruptions from fissures now occupied by picritic dykes. Four such dykes that pass upward into flows have been observed. The lavas and pyroclastic rocks of the upper group represent the products of later central eruptions from a volcano at

Erqa. A large remnant of the neck of this volcano can now be examined for a distance of more than 3 kilometres in the high coastal cliffs at that point.

Lavas and pyroclastic rocks

In addition to their richness in olivine the lavas of the lower group are characterized by a spectacular development of vesticular banding (Fig. 4). It must be emphasized that the zeolitic component of the vesicles constitutes a very considerable part of the bulk aggregate. A typical vesicular band has been chemically analyzed. The most significant figures of percentages by weight are: SiO_2 40.99, Al_2O_3 14.63, CaO 13.86, Na_2O 2.06, H_2O+ 7.18. If such a magma were to crystallize under relatively high hydrostatic pressure, calcic plagioclase would be precipitated in place of lime zeolites. This line of enquiry will be pursued in the light of the experimental evaluation of the hydrothermal stability relations of the plagioclases and zeolites (Goldsmith and Ehlers, 1952; Fyfe, Turner, and Verhoogen, 1958, pp. 167-8; Koizumi and Roy, 1958). In some places along the magnificent cliff section the dark-green picritic rock is represented only by lenses round which sweep the highly vesicular banded facies. At other places individual flows, up to 25 metres thick and exhibiting very little vesiculation, are separated from flows above and below by a reddish, ropy slag or thin layers of tuff, but some sections of highly vesicular flows over 100 metres thick have no such evidence of any pause in lava eruption, and an enormous volume of lava must have been erupted in this part of the Umanak Fjord area in a relatively short space of time. The thick pile of vesicular picritic lavas in the northern part of Ubekendt Ejland may thus represent the tangible remains of an event unique in the history of volcanic activity during geological time.

The upper lava group, which is characterized by much greater diversity, includes olivine-free basalt, monchiquite, trachybasalt, and trachyte. Rhyolite (and pitchstone) is common toward the top of the succession in frequent association with acid pyroclastic rocks. Nepheline-basalt has been found near the acid neck at Erqa.

Minor intrusions

Approximately fifty minor intrusions of picritic type cut the lavas on the cliffs and precipitous mountain slopes of the east and northwest coasts (A to B, Fig. 1). Their occurrence is confined to the lower group of lavas but their distribution is a regional one that bears no relation to the major intrusive centre in the south. The majority of these minor intrusions are vertical or steeply inclined dykes, the remainder being inclined sheets and sills, but the inclination is often variable and the same intrusion may in one place form a vertical dyke and in another an inclined sheet or even a sill.

Geodetic Institute, Denmark. Copyright.

Fig. 2. Air photograph (reproduced by kind permission of the Director, Geodetic Institute, Copenhagen) of the northern part of Ubekendt Ejland taken from the east. Key sketch below shows the location of the picritic intrusions (PD — picritic dykes). The banded vesicular, picritic lavas, which are dipping southwest, are also cut by many other minor intrusions.

Fig. 3. The northern part of the Igdlorssuit Intrusion (shown in black) crossing the peak above the village. Coastal slumping has brought down sections of this intrusion to a point near the village. It is cut by a later basaltic dyke (D).

Irregularity in trend and in width tends to be characteristic of such intrusions. North of Naqerdloq they are beautifully fresh rocks, but farther south they become progressively less fresh, apparently owing to the proximity of the southern complex. All these intrusions are so perfectly exposed that a complete series of specimens can be collected from one quickly cooled, fine-grained margin to the other. No finer array of intrusions of this type has been recorded elsewhere, not even in their classical area of development in the Cuillins of Skye. In addition to variations across such intrusions, lateral variations for distances up to 2 kilometres can be examined in some sheets and vertical variations up to a height of 1 kilometre in several dykes. It should be mentioned, however, that in most dykes the examination of vertical variation over heights of more than 30 metres can only be achieved if the investigator is safeguarded by a fixed rope.

Fortunately, the two finest of these picritic intrusions are also the most easily accessible. They have now been designated the "Igdlorssuit Intrusion" (Figs. 2 and 3) and the "Ingia Intrusion" (Fig. 2), the former corresponding with and including an extension of what were previously referred to as Sheet 2 and Sheet 3; and the latter to Sheet 4 and Dyke 3 (Drever, 1956.) The Igdlorssuit Intrusion is now believed, on the basis of a very detailed field examination in 1957, to be a single, irregular intrusion twice repeated just above the village by slump faulting parallel to the coast that has brought it down from near the top of the mountain peak above. In favourable early morning light this olive-green intrusion can be discerned crossing the eastern face of the mountain. Igdlorssuit is thus not

Fig. 2. Air photograph (reproduced by kind permission of the Director, Geodetic Institute, Copenhagen) of the northern part of Ubekendt Ejland taken from the east. Key sketch below shows the location of the picritic intrusions (PD — picritic dykes). The banded vesicular, picritic lavas, which are dipping southwest, are also cut by many other minor intrusions.

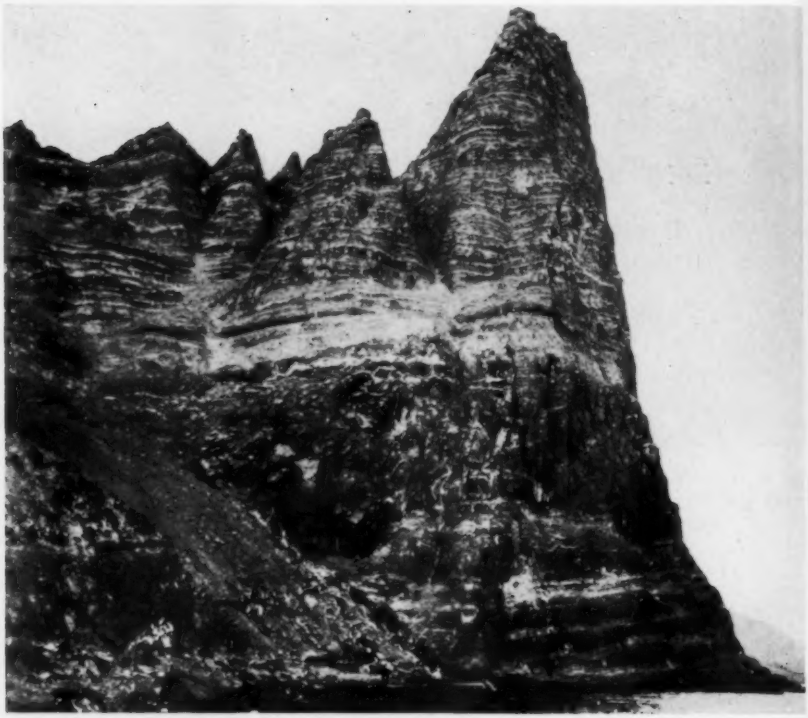

Fig. 4. Prominent peak (150 metres) on coastal cliffs 6 kilometres south of Igdlorssuit. The upper two-thirds of this cliff section are characterized by banded, vesicular, picritic flows in which zeolites are a major constituent. The lower third is characterized by more massive picritic flows in which zeolites are a relatively minor constituent. Dingy (with outboard motor) and two Greenlanders at the foot of the cliff show scale.

only one of the most picturesquely situated villages in Greenland but also a site of much geological distinction. From the crumbling, coarse-grained centre of this intrusion small but clear gem-olivines (peridots) are collected by the villagers. This gravel is about 90 per cent pure, fresh olivine. The Ingia Intrusion is the largest of its kind on the island and is banded near the top (Fig. 5). Specimens of the quickly cooled upper margin were collected in 1957 and the change in crystallization of the olivine and plagioclase from this margin to the centre has been traced in a complete series of specimens.

An important but not yet fully understood characteristic of the margins of most of these intrusions is that the olivines are thinly tabular and skeletal (Drever and Johnston, 1957) and the quickly cooled selvages are picritic, not basaltic. Only toward the centres of the thickest intrusions, including

Fig. 5. Northern exposure of the Ingia Intrusion showing banding near the upper margin, which is within 10 centimetres of the top of the cliff. The bands increase in thickness downward in this picritic intrusion, which at this point is a sill.

the Ingia Intrusion, do the plagioclase feldspars develop as large crystals poikilitically enclosing equant olivines.

The mountains and coastal cliffs in the northern part of the island are intruded by a later group of at least one hundred dykes, and a few inclined sheets of basalt, calcic basalt, or dolerite, tending to be relatively constant in thickness and direction. Individual intrusions vary from about 10 centimetres to 10 metres in thickness. One of the thickest is the prominent sheet that traverses the cliffs north of Igdlorssuit continuously for a distance of 2 kilometres at a height of between 1,500 and 2,000 metres (Fig. 2). This sheet also contains at its margin olivines that are elongated and tabular. Its most characteristic feature, which it shares with many of the basaltic types, is the occurrence of phenocrysts or glomeroporphyritic groups of calcic plagioclase. Two thick members of this group of intrusions are dolerite dykes with zoned, ophitic olivines. Fine-grained, olivine-free basaltic dykes cut not only the lower but also the upper group of lavas.

Acid dykes and sheets, frequently irregular and branching, have been intruded over a wide area around the southern complex and the Erqa volcanic neck (Fig. 1). Many show evidence of explosive brecciation. Their

most intensive development, on coastal cliffs in the south (Fig. 6), is more appropriately described with the southern complex, of which they form an integral part. Here also are composite dykes and sheets with both basic and acid facies. In the same wide area of generally acid dykes some of intermediate composition also occur.

The latest minor intrusions are vertical or steeply inclined dykes that represent a return to ultrabasic material that can best be defined by the term monchiquitic. In their freshness they resemble the early picritic intrusions but differ in the fact that their predominant mineral is not olivine but subhedral augite. Xenocrysts of augite, olivine, or biotite, are common and xenoliths of feldspathic gneiss occur sometimes. Plagioclase is invariably a minor constituent and nepheline-bearing types are rare.

These monchiquitic dykes are developed in very large numbers in well-exposed cliff sections northeast and southeast of Erqa and can be investigated in almost as great detail as the picritic intrusions. They represent a manifestation of igneous activity that is quite clearly related to the centralized eruption of the rocks of the upper lava group, but they cut through all members of this group and also the acid rock that occupies the Erqa vent. It is possible that they correspond to a final phase of eruption in the form of volcanoes of puy type. Only one vent with pyroclastic material of monchiquitic affinity has so far been observed, and much work has yet to be done before the waning stages of volcanic activity on Ubekendt Ejland can be described and interpreted. Monchiquitic rocks have not been recorded anywhere else in the area of Tertiary volcanic activity stretching eastward to East Greenland, Iceland, the Faeroes, Scotland, and northern Ireland.

The southern complex

The cliffs on the south coast (Fig. 6), which here rise to heights of between 300 and 500 metres, constitute natural sections of lavas so injected by felsite and sheets of fayalite-porphyry that in some places there is more injected material than lava. These sheets may vary in direction and width but the majority are inclined toward the northwest at angles of 15 to 20 degrees. This injection zone is only a relatively narrow screen that intervenes, except at one place, between the gabbro of a major intrusive complex and the actual coast.

Particular attention has been paid to the numerous observable contacts between the acid and basic members of composite sheets. There is exceptionally clear and unambiguous evidence of an almost simultaneous emplacement of both components. At some of these contacts fayalite, iron-rich pyroxene and other minerals have been precipitated as a result of reactions. In the first account of the geology of this area (Drever and Game, 1948) it was recorded that the major intrusive mass was essentially sheet-like in form. But re-examination in 1950 proved that this was illusory. It was emplaced vertically, in spite of the fact that the inclination of the banding, layering, and lamination in the gabbro (Fig. 7) is about the same in amount

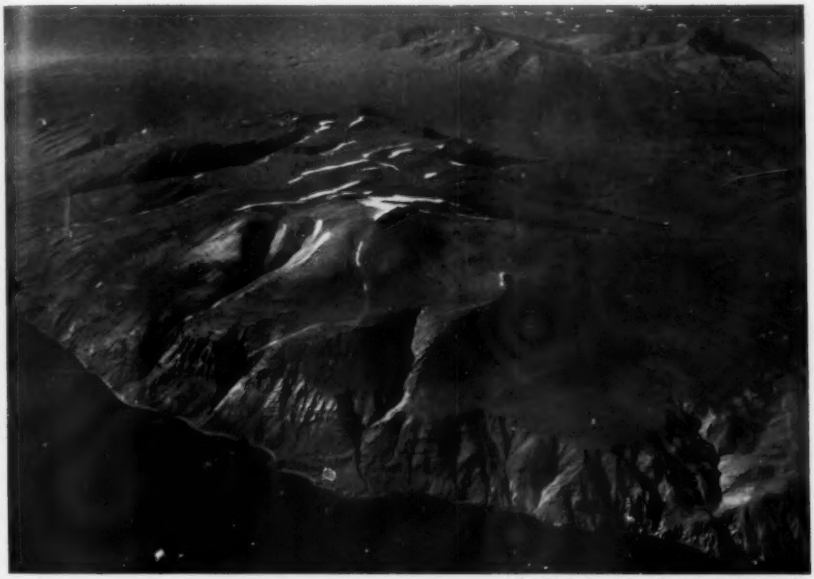

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Fig. 6. Air photograph (reproduced by kind permission of the Director, Geodetic Institute, Copenhagen) of the southern end of Ubekendt Ejland. Light-coloured granophyre of the major intrusion forms the highest ground. The lavas have a westerly and north-westerly inclination and are profusely injected with sheets of fayalite-porphyry and felsite.

and direction as the dip of the lavas and in spite of the sheet-like appearance of the highest and acid part of the intrusive mass. In gullies that transect the cliffs the gabbro can be followed upward and observed to intrude the lavas as irregular tongues. The gabbro is not intruded by the acid sheets, and junctions between them are not clear cut (as between gabbro and lava); transitional rock always occurs. It can be inferred from this that the gabbro was emplaced after the injected acid material but before it had congealed. This view is supported by the fact that in some of the composite sheets and dykes a basic facies is demonstrably later than the acid. In other cases the relations between these two facies suggest simultaneous intrusion and two composite intrusions cut the gabbro. Large rafts of highly metamorphosed lava or, more rarely, of composite sheets may be entirely surrounded by gabbro. Compared with the gabbros in the upper part of the well-known Skaergaard Intrusion in East Greenland (Wager and Deer, 1938) this gabbro is less rich in iron and commonly contains some mica and amphibole.

Above the gabbro is a variety of intermediate rocks containing andesine, quartz, pyroxene, fayalite, hornblende, and biotite, in varying proportions. Above this zone, which does not appear to be more than about 20

metres thick, there is granophyre (and quartz-syenite) to the top of the highest point on the island, 1,141 metres. This acid material is a little less than 400 metres in vertical section. The increase in dip of the lavas immediately to the north of the granophyre must be due partly to inflation when the acid magma was emplaced. The upper part of the intrusive granophyre is in fact the dome-shaped top of a deep-seated mass that has comparatively recently been uncovered by erosion. It is conceivable that very few if any Tertiary plutonic rocks were exposed prior to the period of maximum glaciation in West Greenland.

Current and future research

The research on the picritic rocks of the northern part of the island is now well advanced. Comparative research on similar rocks in the Hebridean area of Scotland has been published or is nearing completion. An experimental approach to the problem of their origin is being undertaken by P. J. Wyllie*. Further detailed factual information on variations in the picritic intrusions was obtained on Ubekendt Ejland in 1957, including their relationship with the picritic lavas. More examples of these lavas are being sectioned, including a representative series from one thick flow, and some are being analysed chemically. This chemical work is financially supported by the Royal Society of London. Twenty chemical analyses (including trace elements) of rocks from the southern complex have been made and over 400 thin sections examined. Preparation of this work for publication has been planned systematically with priority for that on picritic rocks. Several lavas and dykes from the upper group on the west coast have also been chemically analysed and much of the preliminary microscopic work has been completed.

In the investigation of this island, with so much of significance to geology, it would be rash to forecast any finality. There are enough problems for at least four doctorate theses. Future field work should concentrate mainly on the areas away from the coasts, which are largely unexplored, while there is hardly any limit to what can still be achieved on the southern coastal cliffs, where it can truly be said that the tougher the climb the more rewarding will be the discoveries.

Conclusions

On Ubekendt Ejland four British arctic expeditions have discovered some fundamental evidence, exceptionally well exposed, in the following major petrological fields of investigation.

Magmas more magnesian or more calcic than basalt or both.

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Fig. 7. Layered and laminated gabbro of the southern complex exposed in a gully through the cliffs on the south coast of Ubekendt Ejland. A Greenlander is standing in the gully.

Petrogenetic analogy of the massive development of calcic zeolites (in banded lavas) and the anorthositic facies in basic plutons.

Co-existence of acid and basic magmas, their contact phenomena and the products of their interaction.

There are also some other promising lines of enquiry, such as the evolution of the eruptive sequence as a whole.

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EARTH-POTENTIAL ELECTRODES IN PERMAFROST AND TUNDRA

V. P. Hessler and A. R. Franzke*

Introduction

During the past two years the authors installed a number of electrodes in the permafrost and tundra area of Point Barrow to obtain earth-potential data. An earth-potential recording installation consists of a pair of electrodes buried in the ground at a spacing of several hundred feet and connected to a recording millivoltmeter located at some central or convenient location. The instrument records the potential difference variations that appear between the electrodes due to motion of charges in the ionosphere. The data are correlated with other manifestations of ionospheric activity such as magnetic disturbances and the aurora. Thus earth-potential studies constitute an important technique in the general study of the ionosphere.

The resistances of the first set of electrodes increased by several orders of magnitude as ground temperatures dropped during the winter and thus the installation became useless. A second set of electrodes, with sodium chloride incorporated in the fill, proved entirely practical for recording earth potentials. The installations and procedure for determining electrode resistance are described. Data on electrode resistance plotted against time and ground temperature are also given.

The untreated electrodes

The first set of five electrodes was laid out as shown in Fig. 1. The X electrode was installed to give a pair in the geomagnetic meridian, and East was added because of unsatisfactory soil conditions at West electrode. Although the tundra area selected appears quite uniform, the soil at North, South, and X electrodes is clayey, at West electrode it is peat, and at East it is a soil-peat mixture.

The electrodes are lead sheets, 8 feet by 8 inches, cut into inch-wide strips, spread in a crowfoot pattern, and installed in a 6- by 6-foot excavation down to permafrost (Fig. 2). The average depth to permafrost in August 1955 was 12 inches. The excavated material was tamped in carefully around the electrode and then overlaid with sections of tundra vegetation to approximate the undisturbed conditions of the area. Lines were extended from each electrode to a small building that housed the recording equipment.

* Geophysical Institute of the University of Alaska.

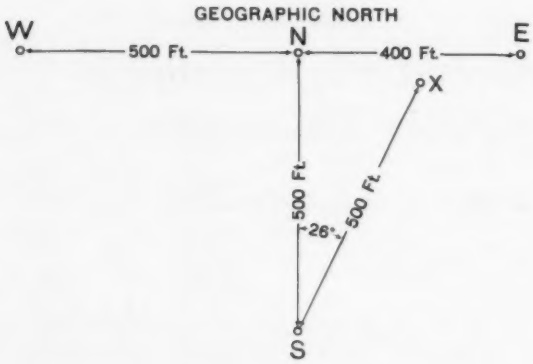


Fig. 1. Layout of untreated electrode set.

Electrode-resistance measurements

All electrode-resistance measurements were made with an ohmmeter of the type used in electronic circuit testing. Electrode pairs were connected to the ohmmeter and readings taken quickly to minimize the effect of polarization. Direct and reversed readings were taken to compensate for the error caused by chemical potential between the electrodes. The average of the two readings, which sometimes differed by as much as 5 per cent, was used to calculate the individual electrode-resistance. The ohmmeter gave resistance values that were sometimes too high, as was indicated by experience with a low-range Megger Ground-Tester that uses an a-c. source and thus eliminates errors due to polarization. However, acquisition of more accurate equipment for measuring resistances would not have been justified because knowledge of the electrode-resistance values was not required for the calibration of the earth-potential equipment.

Resistance readings were taken at frequent intervals between every possible electrode pair and individual electrode-resistance values were calculated from sets of three readings using the following equations:

$$R_1 = 0.5(R_{12} + R_{13} - R_{23})$$
$$R_2 = 0.5(R_{23} + R_{21} - R_{31})$$
$$R_3 = 0.5(R_{31} + R_{32} - R_{12})$$

The subscripts 1, 2, and 3, may stand for any three of the five electrodes. As a check, the resistance of, say N, was calculated in terms of N, S, and W data and again in terms of N, E, and X data. All resistance values presented for the untreated electrodes are averages of two or more such calculations.

Ground-temperature data

Ground-temperature data were supplied by the U.S. Weather Bureau, Barrow Station. The temperature-sensitive devices are thermistors installed at various depths in the quadrangle of the station. The site of the untreated electrode group is in open country about 1 mile from the weather station.

Fig. 2. Form of untreated electrode.

Thus it is probable that the recorded temperatures to a depth of a few feet may vary somewhat from the actual values at the electrodes, particularly during rapid air-temperature changes because of differences in the snow and vegetation cover. Reliable ground-temperature data for September-December 1955 are unavailable because of instrumentation difficulties.

Resistance data for untreated electrodes

Resistance and temperature data for some of the untreated electrodes are presented in Figs. 3 and 4. The resistance-time curves for all 5 electrodes show the same general form. The resistance values of the X electrode lie between those of the N and S electrodes and the resistance values of the E and W electrodes are very much higher. The W, E, and X electrodes attained their maximum resistance values of 194,000, 141,000, and 36,200 ohms, respectively on March 4, 1956. The electrode resistance dropped to a minimum on August 19, 1956 with values ranging from 83 to 397 ohms. These minimum values are essentially the same as the values at the time of installation in late August 1955.

The four temperature curves of Fig. 3 are for ground surface and depths of 4, 11, and 22 feet. The temperature at 1 foot was practically the same as the surface-temperature. A maximum difference of 2.4° occurred during a period of rapid temperature change. The close correlation between the

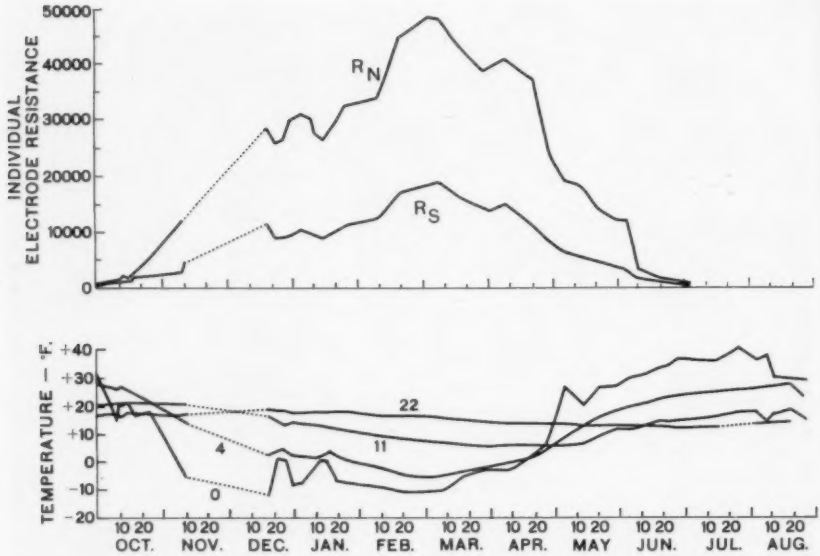


Fig. 3. Resistance and temperature data for untreated electrodes, Oct. 1956 to May 1957.

electrode-resistance and the temperatures near the ground surface is evident in Fig. 3 and appears throughout the more extensive data from which the curves were prepared.

The resistance-temperature relation is also exemplified by the resistance versus temperature locus of Fig. 4. The hysteresis effect may be due to temperature time lag at the greater depths. The series of reversals on the ascending curve corresponds to the December-January data of Fig. 3. It should be noted that the major increase in resistance occurred as the ground temperature at the electrode decreased from 0°F. to −12°F.

The winter electrode-resistance values are far too high for satisfactory earth-potential recording with most recording potentiometers. They are also too high to permit the use of transistor amplifiers that have inherently low input impedance. Vacuum-tube amplifiers overcome the input-impedance problem, but introduce the difficult problem of stability, particularly under field conditions. Thus it was essential to decrease the electrode resistance, if possible.

This could be done by increasing the size of the electrodes. Theoretical considerations show that the resistance of a hemispherical shell electrode, installed with its plane surface at ground level in homogeneous soil, varies inversely with the radius. Applying this relation as a rough approximation to the square outline of the electrodes indicates that the 6- by 6-foot size would have to be increased to a size of 30 by 30 feet to reduce the resistance to 20 per cent of the observed values. This would result in usable values

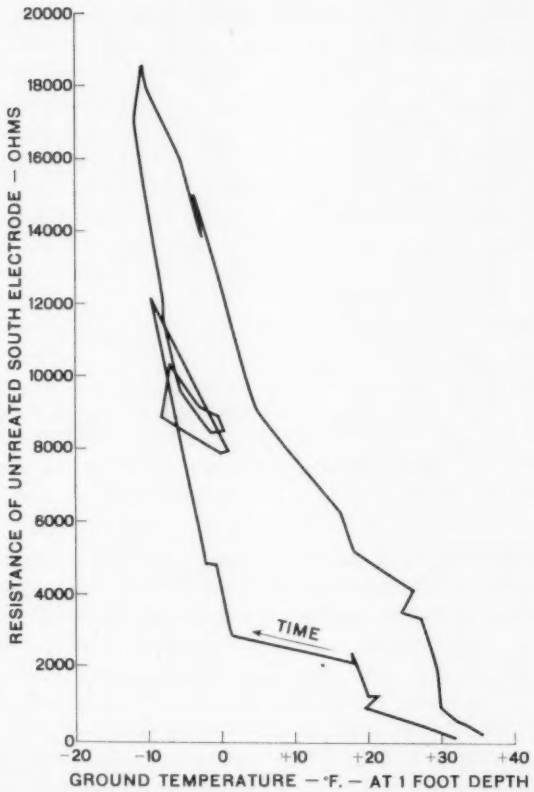


Fig. 4. Resistance-temperature relation for untreated south electrode.

for the N, S, and X electrodes, but not for the very high resistances of the E and W electrodes. Obviously, this solution of the problem is impractical.

The effect of the high electrode resistance could be reduced somewhat by increasing the electrode spacing because the magnitude of the earth-potential voltage is directly proportional to the electrode spacing, whereas the electrode resistance is essentially independent of spacing. However, the increased space and line wires required rules this out as a practical solution of the problem.

Therefore, the only practical procedure for reducing the electrode resistance seemed to be a moderate increase in electrode dimensions and treatment of the fill soil with sodium chloride. Chemical treatment of the fill soil had been avoided previously because of the possibility of introducing variable chemical potentials between electrode pairs.

The treated electrodes

During the summer of 1956 a second set of electrodes was installed in similar terrain and soil about 4 miles from the first set. For the common

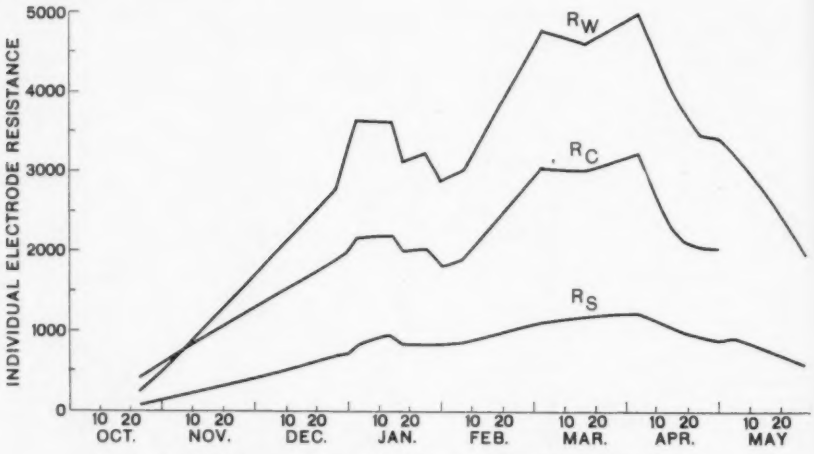


Fig. 5. Resistance of treated electrodes, Oct. 1956 to May 1957.

electrode two concentric circular trenches, 8 feet and 16 feet in diameter and 8 inches wide were excavated to permafrost, which was at a depth of 8 inches. A 50-foot length of 4-inch wide lead strip was placed in the bottom of the outer trench and tamped carefully with sodium chloride-treated soil. A 25-foot lead strip was placed in the bottom of the inner trench and covered to a depth of 4 inches. A second strip was then placed above the first and the fill was completed. One hundred pounds of sodium chloride were incorporated in the fill. Individual lines were extended from the two inner and the outer lead strips to the recording equipment. The West electrode installation is identical with the common electrode.

The South electrode is located at an old beach head, where it was impractical to use the form of the common and West electrodes. There a lead strip about 24 feet long was installed in a trench 12 feet long, 18 inches wide and 24 inches deep and tamped in carefully with the addition of about 50 pounds of sodium chloride to the fill. The spacings between the common and South, and the common and West electrodes are each 1,000 feet.

Resistance data for the treated electrodes

The individual resistances for the treated electrodes during the period October 1956 to May 1957 are shown in Fig. 5. R_c and R_w are the resistance values for the three lead strips of each of these electrodes connected in parallel. The May values of Rc are omitted because the line to the outer loop of the electrode was broken.

The resistance of these electrodes is entirely satisfactory for recording earth-potentials even with the comparatively low input impedance transistor

amplifiers. The low resistance can be definitely attributed to the nature of the installation, because the resistance of the untreated electrodes increased to values corresponding to those of the previous winter.

Much lower resistances than the winter values of these electrodes are desirable for other applications. How should the installation be modified to reduce the resistance further? The resistances of the lines and the electrode material are negligible. Thus, the only possibility of further reduction lies in reducing the contact resistance between metal and soil and the resistance of the ground. It is known that the contact resistance between metal and soil of the treated electrodes is also negligible. The resistance between the two inner lead strips of the West electrode was measured regularly during the test period and it never exceeded 20 ohms. The authors are confident that this low value of resistance is not due to an inadvertent metal to metal contact. A uniform layer of about 4 inches of sodium chloride-impregnated soil was tamped over the lower strip before installing the upper and completing the fill. Furthermore, the highest values of the resistance between the upper and lower strips coincided with the lowest temperatures. A continuous metal circuit would have shown the opposite temperature relation.

Apparently, the resistance of the treated electrodes is due almost entirely to the high resistance of the untreated soil. This suggests treating a considerable volume of soil around the electrode material as an economical means of further reducing the electrode resistance.

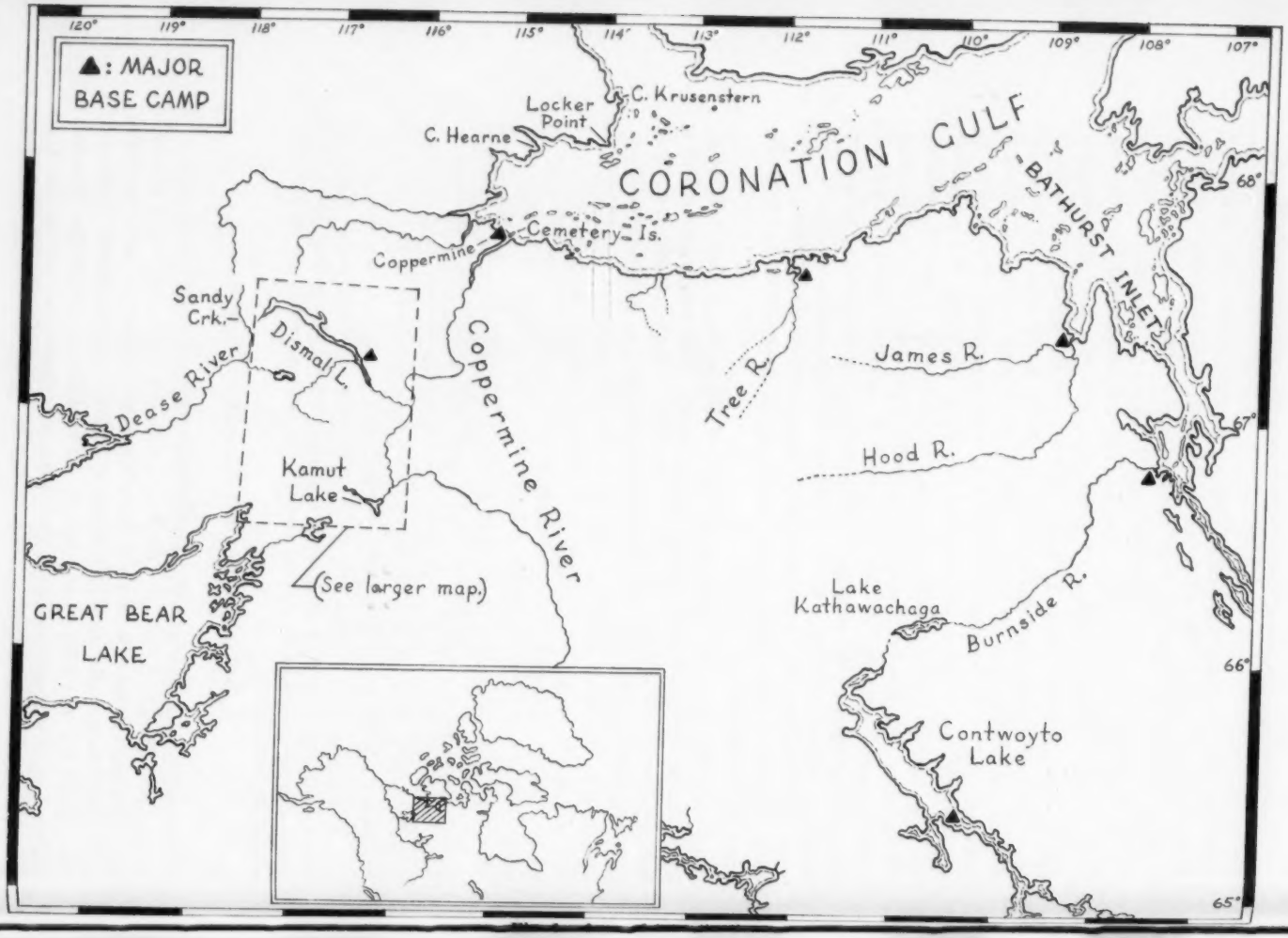
Summary

Untreated electrodes are impractical for earth-potential recording during the winter months in a tundra and permafrost region such as at Point Barrow. There is a close correlation between ground temperatures, to a depth of a few feet, and electrode resistance. A pronounced increase in resistance occurs at temperatures below 0°F.

Electrodes treated with sodium chloride show resistances that are satisfactory for the recording of earth-potentials. Resistances of less than 5,000 ohms can be maintained during the winter with a relatively inexpensive electrode installation.

Acknowledgements

The authors wish to express their appreciation to the Arctic Institute of North America and the Office of Naval Research for the grant (Contracts Nos. ONR-161 and 188) in support for this study; to the Arctic Research Laboratory for logistic support and laboratory facilities; and to the U.S. Weather Bureau for supplying the ground-temperature data.


▲: MAJOR BASE CAMP
120°
119°
118°
117°
116°
115°
114°
113°
112°
111°
110°
109°
108°
107°
Locker Point
C. Krusenstern
C. Hearne
CORONATION GULF
BATHURST INLET
68°
Cemetery Is.
Coppermine
Sandy Crk.
Dismal L.
Dease River
Coppermine River
Tree R.
James R.
Hood R.
67°
Kamut Lake
(See larger map.)
GREAT BEAR LAKE
Lake Kathawachaga
Burnside R.
66°
Contwoyto Lake
65°

PREHISTORY IN THE DISMAL LAKE AREA, N. W. T., CANADA

Elmer Harp, Jr.*

The general survey

THIS paper deals with an archaeological reconnaissance undertaken during the summer of 1955 in certain areas adjacent to Coronation Gulf, N.W.T. The specific aim of the project was to help clarify the cultural development of the Cape Dorset Eskimo and other early peoples of the Eastern Arctic and to link such groups more firmly with ancestral manifestations in Alaska.

The journey was made in company with Ralph E. Miller, M.D., Mary Hitchcock Hospital, Hanover, N.H., in his light plane, a Piper Tripacer. The general scope of the investigation and the exact itinerary have been given in detail (Harp 1955, 1957), but certain broad facts may be restated here.

Much of our time was spent along the arctic coast, mainly around the western end of Coronation Gulf between Cape Krusenstern and the Coppermine River, the estuary and lower valley of the Tree River, the mouth of the Hood River in Arctic Sound, and the mouth of the Burnside River in Bathurst Inlet (Fig. 1). All my collections from these areas are attributable to modern or relatively recent Eskimo.

In the high granite country that borders Tree River on the east we carried out a diligent search for the steatite outcrops that are reputed to have been a major source of material for lamps and pots in the Central Arctic (Jenness 1922, pp. 53-4). It was my hope that evidence of prehistoric quarrying might contribute importantly to our quest, but we failed at first to locate any steatite. Later we flew an Eskimo lad from Coppermine to Tree River and he guided us directly to a quarry where his father had once cut stone. The surrounding area, however, produced only a few modern fragments and uncompleted blanks and there was no evidence of antiquity at the site.

A special trip was made to Locker Point, a few miles south of Cape Krusenstern, in order to examine a peculiar conical stone house on the bluff there (Jenness 1922, pp. 57-8), but no artifacts were found. I plan to make this structure and other similar ones the subject of a future article. Excavation in the coastal zone was undertaken only in the pit of an old sod house on a raised beach along the west shore of Cemetery Island, at the mouth of the Coppermine River. Two occupation floors were detected,

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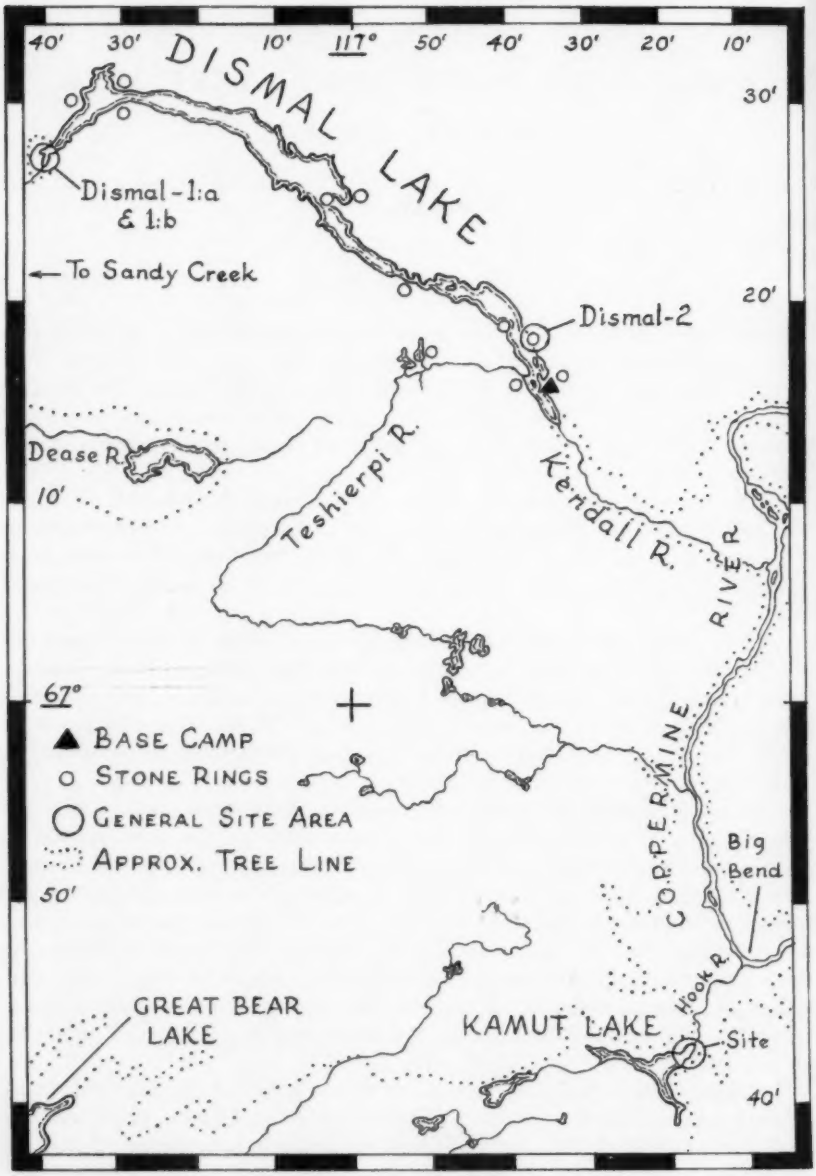

Fig. 2. Area of major sites.

but they yielded only a few fragments of worked bone, none diagnostic, several chips of quartzite, and an interesting juxtaposition of some steatite sherds with earthenware pottery. The pottery fragments are badly eroded, but probably represent a late type.

At Contwoyto Lake, 100 miles southwest of Bathurst Inlet, results were much the same. A week of scouting various esker complexes and the four major embayments of the northeastern shore brought only the discovery of recent hunting camps and caribou drives. Excavation of a stone house foundation on an unnamed island in Burnside River, some 5 miles east of Lake Kathawachaga, also produced only recent artifacts of bone. It was not until we had established our last major base camp at Dismal Lake that several sites of more significant character were encountered (Fig. 2).

In collecting field data in these sites the techniques used were purely of a reconnaissance nature. Once a site had been located it was thoroughly surface-hunted, photographed, and sketchmapped. Except in the two house pits noted, excavation was confined to minor test digs with a trowel to trace surface finds to a given turf horizon.

The sites and their inventories

Dismal — 1:a

This site is situated very close to the western or upper end of Dismal Lake at approximately 67°26′10″N., 117°40′40″W. Three brooks enter the lake there, one at the southernmost extremity and two from the west. Between the two western brooks a large esker curves down to the very edge of the lake where it is eroded in a steep bluff, 30 to 40 feet high, and the site is on top of the esker just above the lake (Fig. 3).

The lake end of the esker is banked with dunes that have been stabilized only once by a thin cover of vegetation; stone chips and artifacts were found both in this thin soil layer and on the surface of the numerous blow-outs that are now modifying the dunes. Signs of occupation begin at the edge of the bluff and go back on the upper surface of the esker. At a height of about 50 feet above the lake the dune sand thins out and disappears and the gravel surface of the esker continues rising westward to a height of 70 to 80 feet. Sporadic finds of chips and stone artifacts were made along the barren ridge for a distance of almost 200 yards from the lake, but the heaviest concentration was close to the lake and appears to have centred on the dunes across the front. Several artifacts were also found near the water's edge where they had fallen during the erosion of the bluff.

Along the upper ridge of the esker were also signs of recent encampments. These included a dozen stone tent rings, several concentrations of broken, calcined bones in probable hearth areas, a severely weathered musk ox skull, innumerable fragments of bone in all stages of decomposition, and wood chips. I could detect no association between these materials and the chipped-stone occupation of the dunes; indeed, no bony material at all was

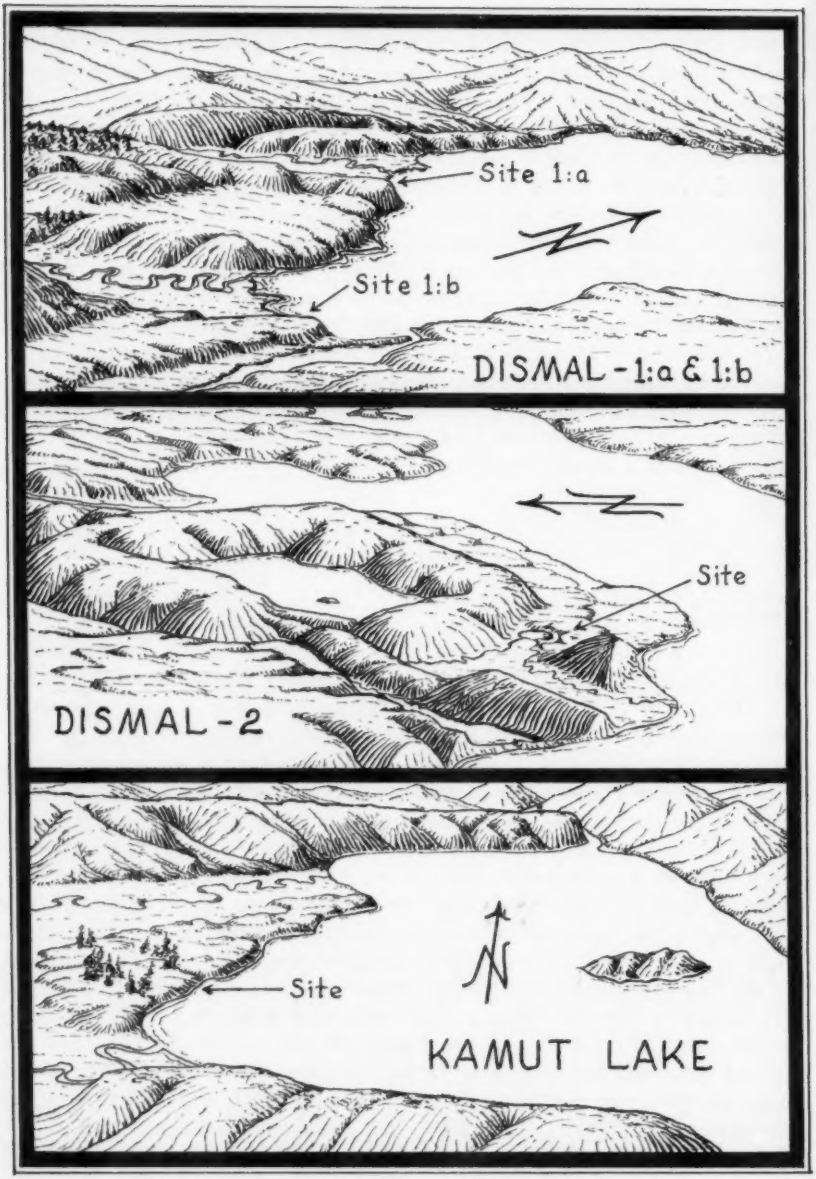

Fig. 3. Sketches of major sites.

found in the dune sand. On the south slope of the esker lay several other tent rings and a badly battered toboggan of Indian origin. These camps were littered with greying wood chips. The material for the wood working came probably from the stand of spruce that clothes the south-facing lee slope of the esker. Some of these trees are 25 feet high with a butt diameter of 12 inches.

The collection from Dismal — 1:a consists of 40 artifacts, 39 of stone and 1 of copper. They are broadly classifiable as: 7 projectile points, 9 knives, 18 scrapers, 1 adz, 1 hammerstone, 3 unidentifiable chipped fragments, and 1 copper implement. Most of them are illustrated in Fig. 4.

Points: Among the 7 specimens found at least 3 types may be distinguished. The majority are lanceolate and Fig. 4, Nos. 2 and 3 are of a type that has its maximum width in the central portion of the blade. Fig. 4, No. 1 suggests a second type in that it is broadest close to the base. Otherwise the 3 specimens are alike in having been made from thick flakes or blades of andesite and andesite-porphyry and all still show the original curvature of the blade along the longitudinal axis. They are biconvex in cross-section, but in all the core face is somewhat flatter. All three are thickest near the point, the original bulbar end of the blade, with No. 3 attaining a maximum of 12.3 mm. The flaking is rough and bifacially staggered so that the lateral edges are markedly sinuous, although No. 2 is more smoothly worked and bears a suggestion of diagonal flaking. The bases are abruptly thinned.

The fragmentary points shown in Fig. 4, Nos. 4, 5, and 6, are similar in shape to the first lanceolate type. No. 4, however, has been made from a relatively much thinner flake, for its maximum cross-section at the break is only 7.4 mm. This may be the basal fragment of a knife, as is suggested by the asymmetry of its lateral edges. No. 6 is the basal portion of a thin flake that has been retouched only at the edges. A third distinct type is represented by Fig. 4, No. 7, a broad corner-notched point of green jasper.

Knives: Fig. 4, Nos. 8, 9, 10, and 11, are all examples of large blades of andesite, basaltic flow rock, or schist, that have been fashioned into knives by retouching portions of or all their edges on one or both faces. No. 9 has apparently been purposefully shaped and almost totally worked on both faces by primary and secondary chipping, whereas the other specimens are characterized mainly by retouched edges. Fig. 4, No. 12 is a discoidal type that seems to have been completely worked on both faces, although much of the underside has spalled away.

Scrapers: The most common type is a large flake or blade that has been steeply retouched along one or more sides, as in Fig. 4, Nos. 13, 14, 16, and 17. The chief materials are andesite, andesite-porphyry, basaltic flow rock, and sedimentary rock. These, as well as the knives mentioned above, are reminiscent of Levalloisean artifacts. No. 14 has a continuous edge preparation that makes it both a side and an end scraper. Fig. 4, Nos. 18, 19, and 20, are the common type of snub-nose or steep end scraper. A third type is represented by Fig. 4, Nos. 15 and 22; both are thick, heavy side scrapers.

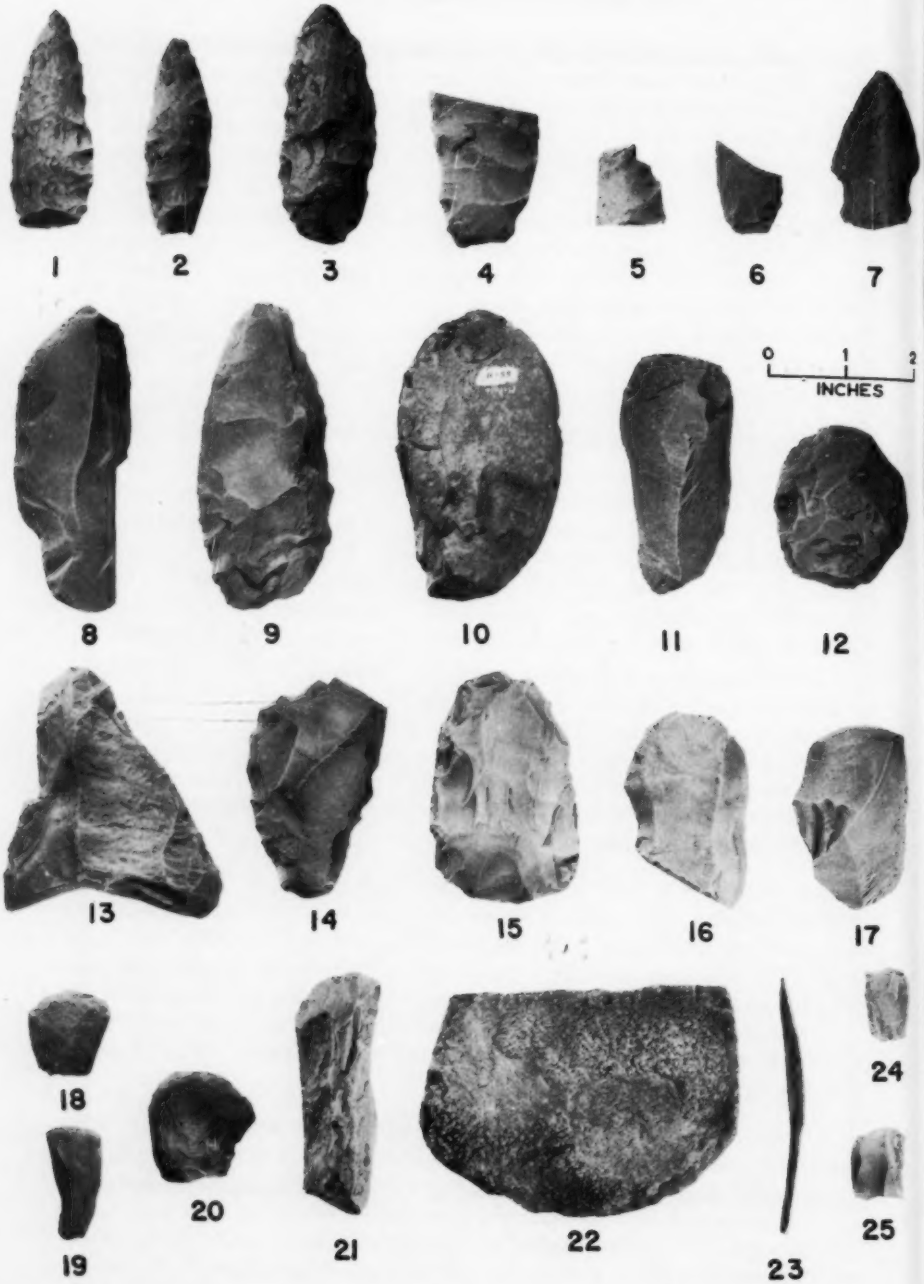

Fig. 4. Artifacts from Dismal — 1:a.

No. 15 has been roughly flaked from a core of metamorphosed sedimentary rock and No. 22 is a spall from a granite boulder with a maximum thickness of 1.7 cm. The convex bottom edge has been chipped on both faces and the exterior face still bears portions of the cortex of the original boulder.

The artifacts shown in Fig. 4, Nos. 24 and 25 may be classed as small flake knives or as scrapers, but they do not partake of the general character of this assemblage. They are made of flint and more closely resemble artifacts of the microlithic industry of Dismal — 2.

Adz: I have called Fig. 4, No. 21 an adz because its nose is steeply flaked and the edge scarred. Undoubtedly, however, it saw much use as a scraper or flesher, for its flat undersurface is polished quite smooth. Beneath the polish signs of earlier primary flake scars are still visible.

Hammerstone: This specimen, not illustrated, is a granite pebble, oval in shape and cross-section that has been flattened at both ends through pecking and pounding. The longest axis, between the worn ends, is 11.6 cm. and the weight 2 lbs. 4 oz.

Copper: The artifact in Fig. 4, No. 23 is a perforator or thin blade that has been cold-hammered from native copper. It cannot with any certainty be linked with the chipped-stone industry of the esker dunes and quite probably is recent.

Dismal — 1:b

It is probable that the occupation of the esker dunes extended to this site and I tentatively consider the two localities as related components. Dismal — 1:b is situated at the mouth of the brook that flows into the southern extremity of the lake; it is about 200 yards from the esker of Dismal — 1:a. The site lies on a flat-topped sandy knoll that is bounded by gravel slopes on the lake and brook sides. The surface stands 15 to 20 feet above the present lake-level, and a considerable concentration of stone chips and a few artifacts lay scattered over it, covered here and there with patches of thin vegetation and lichens. There were also many fragments of weathered bone, but since a number of them lay on top of the vegetation they surely had no connection with the chipped-stone remains.

Only 6 artifacts were collected from the surface of Dismal — 1:b. They include a projectile point, 2 knives, 2 scrapers, and an unworked microblade.

Points: The lone specimen is a corner-notched type shown in Fig. 5, No. 1. The material is not identifiable because of heavy patination.

Knives: Fig. 5, No. 2 is the basal fragment of a thin broad blade or spear point, which is very similar to Fig. 4, No. 4. Both specimens consist of basaltic flow rock and are completely worked bifacially. Fig. 5, No. 3 is a scraper fragment that shows much less careful workmanship on metamorphosed sedimentary rock. The lateral edges have been chipped on both

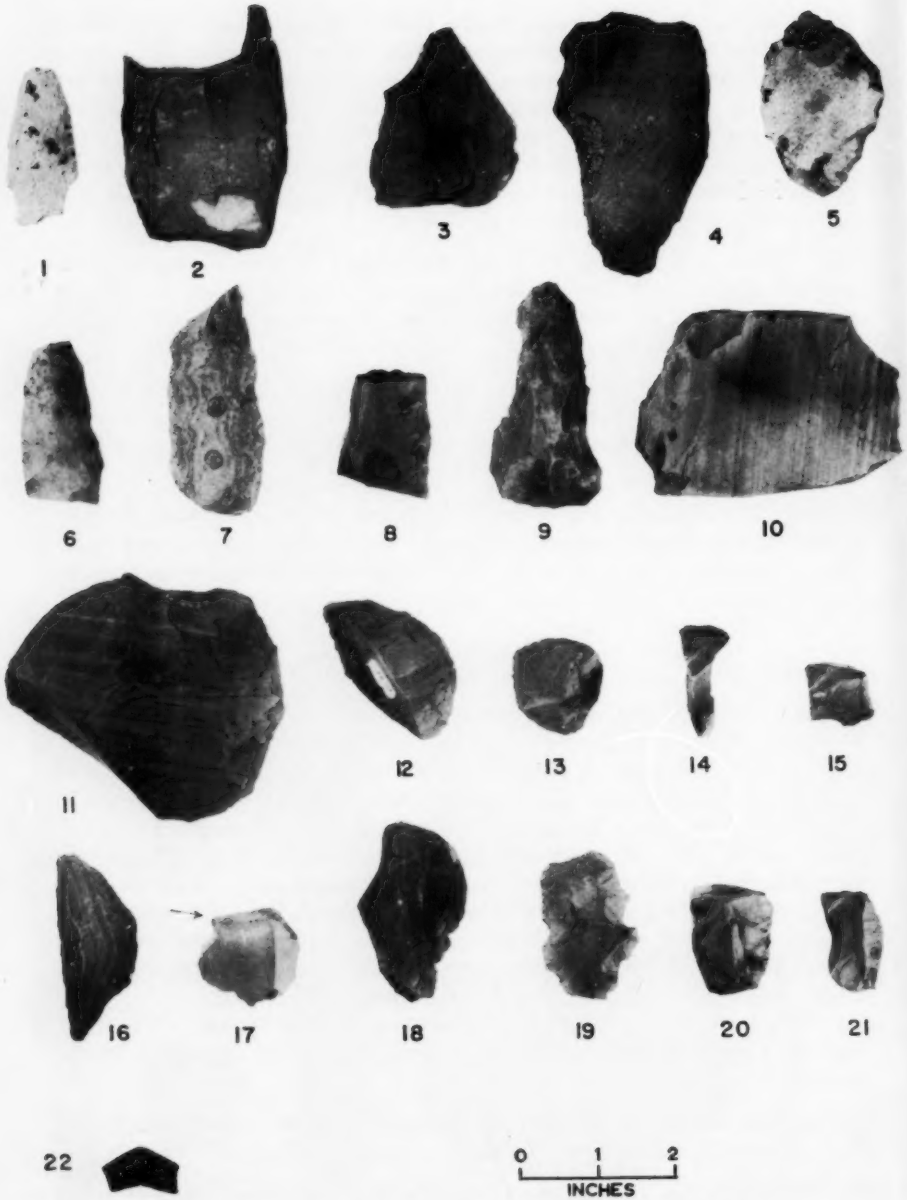

Fig. 5. Artifacts from Dismal—1:b (Nos. 1 to 5) and Dismal—2.

faces, but its most interesting attribute is the portion of a ground or polished facet at its uppermost tip. Presumably a ground edge once extended across that end of the implement, but only 7.5 mm. of it now remain. The depth of the bevel is 9.9 mm. and the angle 47°.

Scrapers: Fig. 5, Nos. 4 and 5 are both side scrapers made on flakes of andesite-porphyry. No. 4 is another Levallois-type flake, much like the specimens from Dismal — 1:a and No. 5 is a strongly concavo-convex flake struck from the exterior of a pebble and still bears the patinated cortex on its outer surface.

The microblade is not illustrated and will be mentioned in connection with Dismal — 2.

Dismal — 2

This site is located about 30 miles east of Dismal — 1 on the north shore of the lake at approximately 67°18′30″N., 116°38′45″W. The shoreline here projects slightly around the base of an esker complex that encloses four ponds (Fig. 3). The site lies just south of the smallest and southernmost of the ponds on a low ridge between higher portions of the esker and appears to be a beach formation. The surface of the ridge is 25 to 30 feet above present lake-level, and the pond lies behind it in a depression some 5 feet lower.

The ridge is composed of bedrock and gravel, it has been partly drifted over by dune sand and has been weakly stabilized by heath vegetation. Evidently it has long been a favourite camp site, for it carries traces of perhaps three different occupations. Two of these are characterized by chipped-stone remains and the third by recent Eskimo remains. The last occupants left six stone tent rings along the ridge for over 200 feet and were no doubt responsible for breaking the shallow plant cover. As a result, the surface is pockmarked by blow-outs that were littered with stone chips and artifacts. Evidence for a sequence of occupations must be based on typology, for there was no indication of stratification. The chipped-stone remains were scattered over an irregular area of about 30 by 100 feet.

One of the two main components of the site, excluding recent Eskimo, is based on a large flake industry that is quite like that from Dismal — 1:a and 1:b. Twenty specimens may be attributed to it: 17 are chipped, 1 is polished, and possibly 2 are of native copper. They include 4 points, 1 knife, 6 scrapers, 2 choppers or large steep end scrapers, 1 core, a fragment of a steatite pendant, and the copper specimens.

Points: Fig. 5, Nos. 6 and 7, although not complete, somewhat resemble the lanceolate type Fig. 4, No. 1. But No. 7, with a maximum thickness of 7.5 mm., is relatively thinner. No. 8 is a fragment of the same type and No. 9 another badly eroded sample. They are all of sedimentary rock.

Knives: Fig. 5, No. 15 is the only probable specimen of a knife from this site. It is of flint and bifacially worked along both edges and may be part of a longer blade.

Scrapers: The largest type is represented by Fig. 5, Nos. 11 and 12. They are plano-convex in cross-section and made from very large flakes or cores of sedimentary rock. The convex working edges have been fashioned by a combination of pressure flaking and unresolved step flaking, as if they had been used as choppers. The more usual type of small, snub-nosed end scraper is represented by Fig. 5, Nos. 13 and 14. Side scrapers fashioned on random flakes are Fig. 5, Nos. 16, 17, and 18. Of these, No. 17 appears to have been a tool of many uses. It is a flake of green jasper that has a short straight scraping edge (uppermost), a minutely flaked concave scraping edge with a radius of 3.2 mm. (left), and a beaked engraving tip that was formed by the removal of a burin spall (upper left). I have not classed this as a burin for the reason that it curiously seems to have been used in reverse. The arrow in the photograph indicates how the burin blow was delivered and the negative bulb of percussion lies adjacent to the upper corner of the concave scraping edge. The general shape of the tool at this corner, however, seems to spoil the usefulness of the concave chisel edge. At the opposite (right) end a small beak was formed where the burin spall broke away from the flake and the use of this as an engraving tip is suggested by several minute step-flake scars just below its extreme tip.

Various: Fig. 5, No. 10 is a core of sedimentary rock and 19, 20, and 21, are unidentifiable worked fragments. No. 22 appears to be the mid-section of a steatite pendant. This specimen is 2.5 mm. thick and the hole has been drilled from both sides. The ornamental incised groove also appears on both faces. It is not possible to associate the pendant and two fragments of native copper (not illustrated), one of them definitely cold-hammered, with the large flake industry described. These artifacts may well belong to the late Eskimo occupations of Dismal — 2.

The microlithic industry

Until the discovery of this site the single microblade and the two small flints found at Dismal — 1:a and 1:b had constituted puzzling aberrants. In the blow-outs of Dismal — 2 the proportions were drastically reversed and the microlithic specimens considerably outnumbered the large artifacts. The latter were more or less evenly distributed through the blow-outs in this site, but the microliths were not as widely scattered. In all, 73 microlithic specimens and 48 unworked microblades were collected. They include 12 projectile points, 4 side blades, 8 knives, 8 burins, 3 unworked burin spalls, 5 burin spall gravers, 2 specialized micro-gravers, 12 used microblades, 2 specialized quartz tools, 8 scrapers, and 8 worked fragments that are not identifiable.

Points: Fig. 6, No. 1 represents a small, but thick, leaf-shaped type. The cross-section is biconvex and the flaking bifacial. The left-hand specimen, however, differs in being triangular in cross-section; the face shown has a steep median ridge and its surface is entirely worked, whereas less than

half of the flat core face beneath is worked. The tip fragments in Fig. 6, No. 2 constitute a second and thinner leaf-shaped (?) type. They are noteworthy for the skillful retouching along their finely serrated edges. No. 4 consists of possible base fragments of similar points. No. 3 is shown as if it were a tapered point, but it may be as well a basal fragment with a tapering stem. No. 5 appears to be an unfinished blank.

Side blades: One whole specimen and three fragments are pictured in Fig. 6, No. 6. The former has been delicately pressure flaked all over both faces with perhaps the faintest hint of a diagonal direction. The three others have portions of unmodified blade surfaces on one or both faces.

Knives: Fig. 6, No. 7 is a crescent-shaped type that is marked by very slight shoulders near the middle of each edge. The basal fragments shown as No. 9 also seem to be portions of knives, although they do not have any signs of shoulders. Another type with a sub-rectangular shape, possibly a side blade, is represented in No. 8. These implements are made of thin blades and have a flat, unworked core surface and a convex dorsal face that is more or less completely flaked. The two flint specimens found at Dismal — 1:a (Fig. 4, Nos. 24 and 25) undoubtedly are of the same type and as such do not appear to be in context with the large flake industry in which they occurred.

Burins: The 8 burins are all of the angle type, as shown in Fig. 6, Nos. 10, 11, and 12. No. 10 has been formed on a basally thinned blade that is carefully worked on both faces. On the edge opposite the burin spall scar is a narrow shoulder that makes this tool reminiscent of the curved knife shown in No. 7. The two specimens illustrated as No. 11 are both angle burins on side scrapers. They, as well as No. 10, are obviously large enough to give spalls of sufficient size for modification into micro-tools. On the other hand, the 5 examples shown as No. 12 are too small as sources for workable burin spalls. They have all been fashioned on thin-bladed knives akin to the type in No. 8.

In addition to the burins, 8 burin spalls were collected at Dismal — 2. Five, illustrated as Fig. 6, Nos. 14, 15, 16, and 17, are clearly the same as the burin spall artifact that Giddings (1956b) discovered and described. They are minutely retouched across the end opposite to the bulb of percussion. According to Giddings's analysis the retouched end of No. 14 is slanted to the left and this presumably indicates left-handed use. This artifact is a primary spall. No. 17 slants to the right and Nos. 15 and 16 have worked edges at right angles to the longitudinal axis. The spalls in No. 16 are grouped separately because each is purposefully notched at the right corner of the prepared edge. Giddings does not mention this as an attribute of any of his burin spall artifacts, but one of those that he illustrates appears comparable (1956b, Pl. 1, No. 2). Three other spalls, shown in Fig. 6, No. 13, have no sign of retouch, but they show the considerable size range in these tiny artifacts. For contrast see the very large burin spall graver from Kamut Lake, Fig. 7, No. 8.

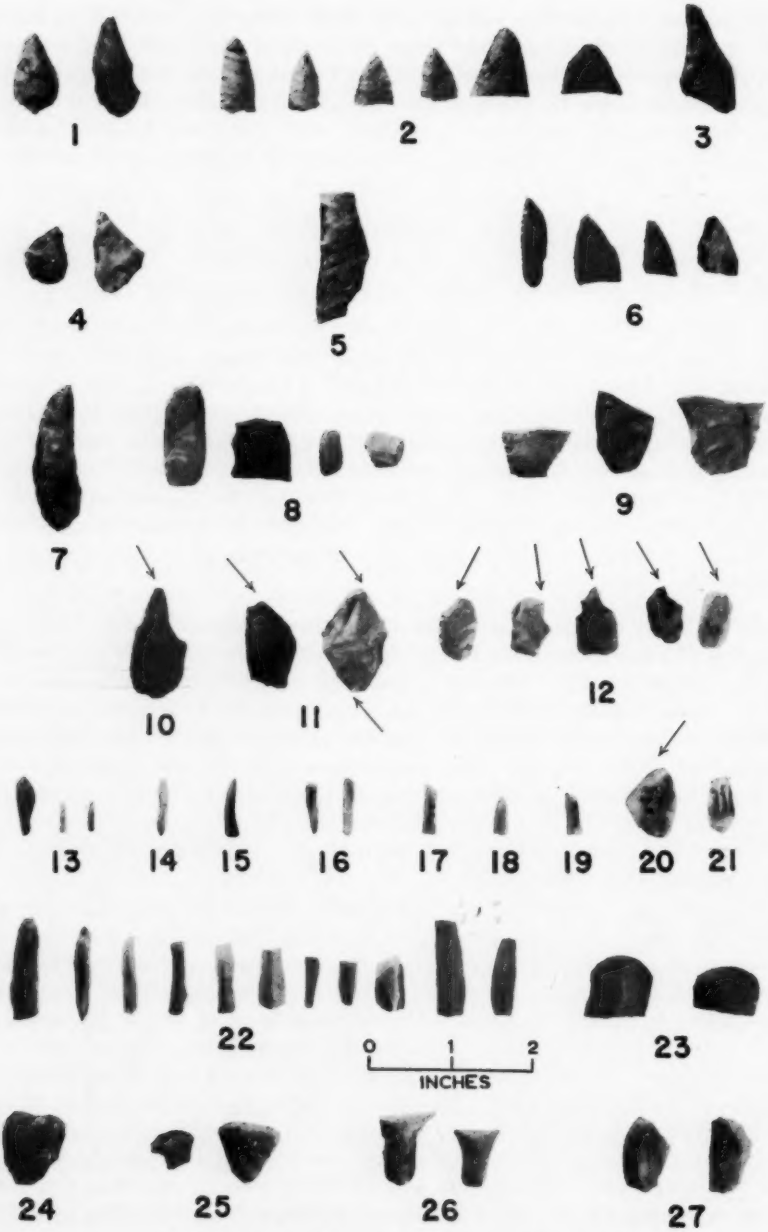

Fig. 6. Microlithic artifacts from Dismal — 2.

Specialized micro-gravers: Fig. 6, Nos. 18 and 19 are unique tools in the collection. Both have been fashioned on faceted microblades by a process of minute retouching at one end. No. 18 has a thin, sharp, symmetrical point unifacially retouched on both edges, whereas No. 19, although worked similarly, has a heavier, blunter point that is hooked to the left. Perhaps these artifacts are functionally related to those made from burin spalls, but they are based on a variety of microblade.

Used microblades: Fig. 6, No. 22 illustrates those microblades in the collection that show signs of modification through use. Most often these are in the form of a series of step-flake scars along one or both lateral edges, but in several an edge appears to have been purposefully retouched. Otherwise these lamellar microblades are similar in size and proportion to the 48 unused, unworked microblades found at Dismal — 2.

Specialized quartz tools: The two implements shown in Fig. 6, Nos. 20 and 21 are both made from quartz crystals. No. 20 is a flake that has been removed from the end of such a crystal and its upper surface is formed by four of the original crystal facets. Its lower end has been retouched into a flat end scraper; the upper end may be an angle burin, although I am not absolutely certain of this. No. 21 is a gouge or chisel made by removing several longitudinal flakes from opposite faces at one end of a small quartz crystal.

Scrapers: All specimens in this category are steep end scrapers. Fig. 6, No. 23 shows two examples of a type with parallel sides; the scraper with the ridged back is made of a flake of green jasper and should perhaps more properly be associated with the large flake industry, for it strongly resembles some of the Kamut Lake specimens of that classification (cf. Fig. 7, Nos. 15 and 16). No. 24, made of greyish obsidian, is of thick, triangular form. No. 25 consists of a thin, triangular type that could easily have been hafted, and No. 26 shows a stemmed type that has a straight working edge and sharp corner tangs. The final two specimens, No. 27, represent a still different shouldered type. They are not exactly alike, however, for the left-hand scraper has a concave working edge above its shoulder, whereas the other is convex there.

Kamut Lake

This site is located on the eastern arm of Kamut Lake at approximately 66°43′10″N., 116°17′20″W. (Fig. 3). Along the western shore of this arm is a broad embayment, the outer points of which are formed by an esker on the south and a long high ridge on the north. The land between these ridges is low and partially covered with spruce and willow. Along the middle of the bay a gravelly plateau parallels the shore and projects eastward to form a point. The site is in dune sand on top of this eminence at an average altitude of about 20 feet above the present lake-level. As in

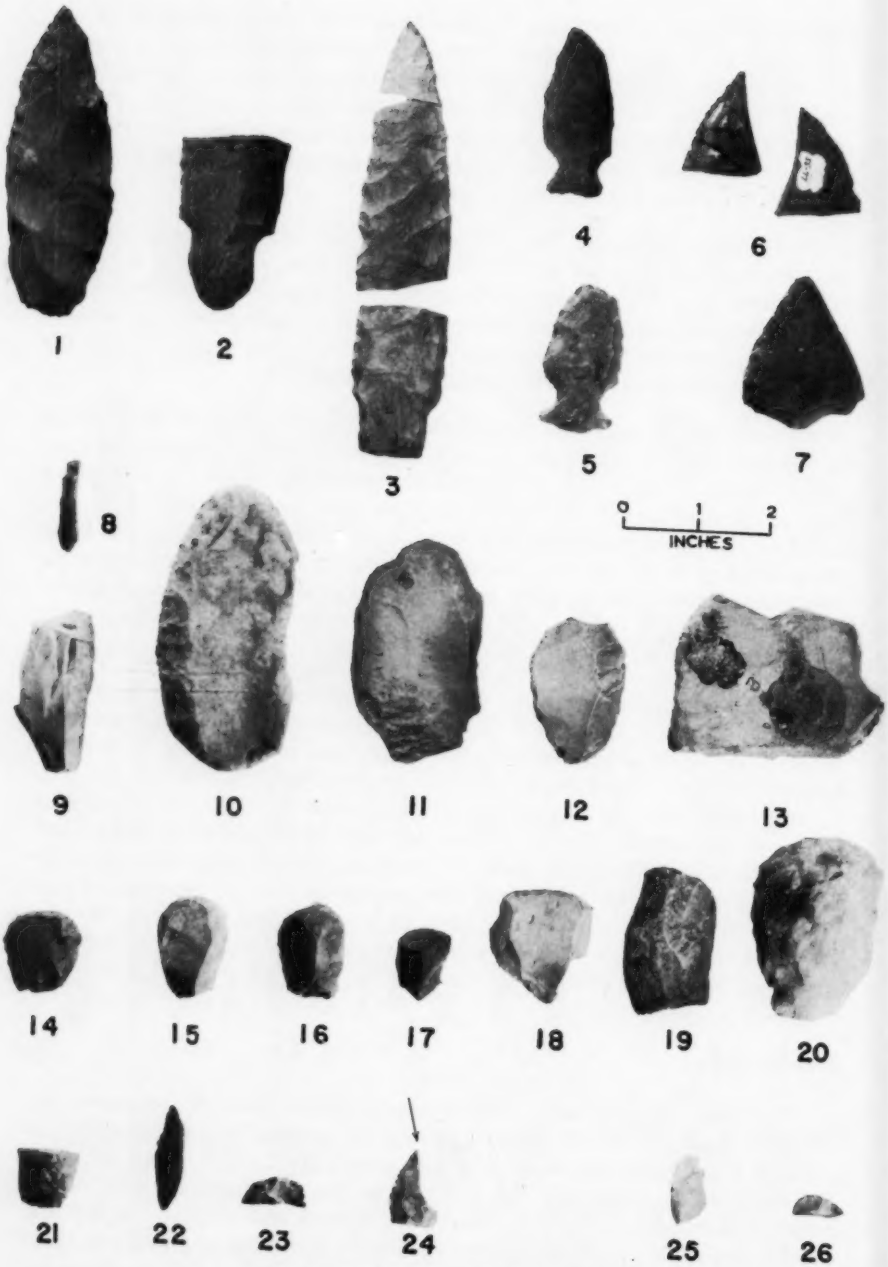

Fig. 7. Artifacts from Kamut Lake.

the Dismal Lake sites, the dunes have been stabilized by a very scanty vegetation and blow-outs have developed wherever this cover has been breached.

Over an area roughly 100 yards in diameter these blow-outs were found to be liberally sprinkled with stone chips and artifacts and many small fragments of weathered and burnt bone. This bone debris probably must be attributed to the same occupation as the chipped stone, for there were no signs of recent encampments in the immediate vicinity. The Kamut Lake site is further comparable to Dismal — 2 in that it contained possible evidence of two occupations: the large flake industry and the microblade industry.

Large flake industry

To this category may be assigned 31 artifacts; they include 5 projectile points, 2 knives, 19 scrapers, 1 burin, 1 burin spall graver, and 3 unidentifiable worked fragments.

Points: All specimens found are illustrated in Fig. 7 and represent at least 4 types. No. 1, a large lanceolate type chipped from a blade of sedimentary rock, resembles very closely the Dismal — 2 point shown in Fig. 5, No. 7; the flaking is broad and bold on both faces, the edges sinuous and the base thinned. No. 2 is the basal portion of a massive stemmed point of rhyolite porphyry. Its biconvex cross-section has a maximum thickness of 11.9 mm. at the break and this same median thickness continues virtually undiminished down through the stem to the point where the radius of the bottom curve begins. The primary flaking is shallow and smoothly done on both faces and there is a bifacial secondary retouch on the edges. The entire periphery of the stem is ground to a dull smoothness. No. 3 is a long, stemmed type of sedimentary rock. The primary flaking is broad and shallow, occurring mostly on one face and there is a secondary retouch of the edges on both faces. It is much thinner than No. 2, for its maximum thickness is only 7.6 mm. The straight-sided stem is expertly thinned bifacially, its lateral edges are ground smooth. The fourth type of projectile point is represented by two side-notched specimens, Nos. 4 and 5, that are bifacially flaked from sedimentary rock.

Knives: The 2 knives collected at Kamut Lake are also made of sedimentary rock. Fig. 7, No. 6 consists of two pieces that I believe to be parts of one artifact, although the broken edges do not match. Each is fashioned from a thin flake or blade that has been bifacially chipped only around the outer curved edge. No. 7 appears to be the basal portion of a large thick blade that shows both primary and secondary flaking.

Burins: Fig. 7, No. 9 is a corner burin on a blade of green jasper. Two spalls have been removed from the left edge, but the shape of the upper end is such that the chisel could not have been used to the best advantage.

A single burin spall artifact, No. 8, was also found in this site and although it too is green jasper it does not derive from the burin just described. Giddings, who had a brief opoprtunity to see these collections, observed that this particular specimen was the largest burin spall artifact he had ever seen. It measures 32.3 mm. long, 7.3 mm. in maximum width, and 4.2 mm. in maximum thickness and according to Giddings's classification is left handed.

Scrapers: The several types in this category, which was by far the most plentiful at Kamut Lake, are illustrated in Fig. 7, Nos. 10 to 20. Nos. 10 to 12 may be classed as side scrapers on blades; one or both lateral edges of these implements have been retouched and the workmanship of No. 10 is particularly fine. Side or end scrapers made on random flakes are shown in Nos. 13 and 18. Two types of steep end or snub-nose scraper are also clearly evident: No. 14 is a thin chip end scraper and Nos. 15 and 16 constitute a type with a faceted, ridged back. No. 17 also has a high ridged back, but it seems to have been made from a remnant of a green jasper core rather than a flake. No. 19 is a combined end and side scraper of black andesite and No. 20 is one of four quartzite turtleback scrapers in the collection.

Microlithic industry

Twenty-three specimens can be attributed to this industry as it appeared in the Kamut Lake site. They include 2 projectile points, 1 fragment of a knife, 2 angle burins, 3 scrapers, and 15 fragments of unworked microblades, the latter all of quartzite. With the exception of the microblades, which occurred together in one small patch of blow-out in association with two snub-nosed end scrapers, the artifacts were found scattered over the area in haphazard mixture with specimens of the large flake industry. Inasmuch as there was no stratification in the site, this fact suggests that a single occupation was responsible for both types of remains.

Points: The fragment shown in Fig. 7, No. 21 is probably the base of a small lanceolate point, but it could possibly be the stem of a larger point, as is suggested by the slight hint of a shoulder at one corner of the break. It is bifacially flaked and retouched at the edges; several minute longitudinal flakes have been removed from one face at the base. No. 22 has been made from a blade-shaped spall of some indeterminate rock. Its appearance suggests a side blade, but the thickness of the lower end may indicate end-hafting.

Knives: The only example is Fig. 7, No. 23, a fragment of banded chert, which could be the base of a biface knife or possibly a projectile point.

Burins: Two specimens of angle burin were found here. The one shown in Fig. 7, No. 24 resembles most the Dismal — 2 burin in Fig. 6, No. 10, even as far as the suggestion of a shoulder on the right edge and it has had

5 spalls removed. The other, not illustrated, is akin to the Dismal — 2 burins shown in Fig. 6, No. 12; it has had two minute spall struck off one edge.

Scrapers: Fig. 7, No. 25 is a side scraper made on a thin blade of flint, but it might also be a fragment of side blade. No. 26 is a fragment of snub-nosed end scraper.

Microblades: As noted above, these 15 fragments do not show any sign of modification.

Relationships within the Northwest Territories

The relationships among the Dismal-Kamut sites are not easy to define because the evidence is rather scant. However, I believe that one combination is slightly more likely than other possibilities: this includes one complex that covers Dismal — 1:a and 1:b, a separate complex for Dismal — 2, and a third one for Kamut Lake.

The Dismal — 1 sites are adjacent to each other and even though very few specimens are available from Dismal — 1:b, they are similar both in types and materials. More specifically they share the thin-bladed lanceolate point or knife (Fig. 4, No. 4 and Fig. 5, No. 2), corner notches on other points (Fig. 4, No. 7 and Fig. 5, No. 1), the thick form of side scraper (Fig. 4, No. 15 and Fig. 5, No. 3), the Levallois-like side scrapers (Fig. 4, Nos. 13, 14 and Fig. 5, No. 4), and each site produced one implement that combines the techniques of chipping and polishing (Fig. 4, No. 21 and Fig. 5, No. 3), although this last comparison is weakened by the different functions of the two. As for materials, approximately one half of the artifacts from each Dismal — 1 site are made either of andesite-porphyry or basaltic flow rock and the artifact types are alike in each of these materials. The presence of a single unused, unretouched microblade in Dismal — 1:b is completely inexplicable in this context. Until it may be accounted for by some future excavation at this site, I must attribute it to a careless hunter who was passing down the lake to Dismal — 2.

The sites at Dismal — 2 and Kamut Lake seem to be distinctly different from the Dismal — 1 complex for the following reasons: each of the former contains a strong component of microlithic artifacts, the prevalent raw materials differ, the diagnostic types of projectile points and end scrapers are different, and they do not have a high incidence of Levallois-like flakes.

As for similarity between Dismal — 2 and Kamut Lake, a tenuous linkage is possible. In their large flake industry components they share one type of lanceolate point (Fig. 5, No. 7 and Fig. 7, No. 1), crude burins (Fig. 5, No. 17 and Fig. 7, No. 9), and possibly turtleback scrapers (Fig. 5, No. 12 and Fig. 7, No. 20). In addition there was evidently a predilection at these two sites for the use of sedimentary rock and green jasper for the manufacture of the same or comparable types of tools. In what I distinguished as microlithic components they definitely share only two types

of burins. To these might be added two types of snub-nosed end scrapers, but that is all.

On the other hand, the differences between Dismal — 2 and Kamut Lake appear to be clearer and more weighty. In the large flake industry Kamut Lake stands apart by virtue of its two types of stemmed points and side-notched points, its large flake side scrapers, and its keeled end scrapers. In the microliths Dismal — 2 shows a far greater diversity of types than Kamut Lake and finally the two sites differ widely in the numerical proportions of their basic component technologies. At Dismal — 2 the ratio of microlithic to large flake artifacts is 4:1, at Kamut Lake 1:4.

There is, of course, one final possibility: the microlithic components at each of these sites may represent a separate, discrete occupation. There is no stratigraphic evidence to support such a view, however, and certainly one cannot depend entirely on the faint suggestion of spatial segregation that was observed at Dismal — 2; even this was not borne out at Kamut Lake. On the basis of internal evidence, then, I believe the analysis of the complexes must be essentially as I have indicated and we must turn to comparisons with peripheral areas for further clues.

The sites examined by MacNeish at southwestern Great Bear Lake are geographically closest, some 300 miles overland around the lake, and thus might well be part of the ancestral line to Dismal and Kamut. The earliest of three occupations at Great Bear Lake, the Franklin Tanks complex (MacNeish 1956a), shows a few weak resemblances in the scraper category, where wide-ranging distributions reduce the significance of such criteria, and none at all in the primary diagnostic traits, such as small concave-based points and another type that MacNeish equates with Plainview.

The middle stratum, called the Great Bear River complex, is more productive of resemblances. One of its essential criteria, the lanceolate point identified by MacNeish as Angostura (1956a, p. 64), seems to be duplicated by the long points from Dismal — 1:a, and the correlation spreads further among triangular keeled scrapers (Fig. 7, No. 15), flat keeled end scrapers (Fig. 6, No. 23, left), thin flake side scrapers (Fig. 4, No. 11; 5, No. 18; 7, Nos. 11 and 12), used flakes, ovoid blades (Fig. 4, No. 12), and choppers (Fig. 4, No. 22). Less certain resemblances occur for truncated triangular end scrapers, large flake single convex-edged side scrapers, and semi-lunar blades. Types that do not appear at all in the Dismal-Kamut inventories include narrow round-based points, small pentagonal points, triangular drills, long crude drills, and Yukon flake knives.

The latest Great Bear stratum, the N.T. Docks complex, shows the closest linkage of all three levels to the Dismal-Kamut materials. Again using MacNeish's more elaborate typology, the following correspondences are evident: side-notched points (Fig. 7, Nos. 4, 5), lamellar blades (Kamut Lake, not illustrated), crude burins or burin-like tools (Fig. 5, No. 17 and 7, No. 9), triangular keeled end scrapers, fan-shaped snub-nosed end scrapers (Fig. 4, No. 18; 2, No. 13; 7, No. 14), convex end-of-the-blade scrapers (Fig.

4, No. 19), flat-topped square-ended scrapers (Fig. 7, No. 18), thin flake side scrapers, large flake side scrapers, keeled side scrapers (Fig. 4, No. 16 and 7, No. 9), square-based blades (possibly Fig. 5, No. 2), and battered flint nodules, which, if they were hammers, may be duplicated by the specimen described from Dismal — 1:a.

These trait linkages, although they cut to some extent across at least two of the Dismal-Kamut complexes, seem to weigh in favour of a relationship between the Great Bear River and Dismal — 1 complexes on the one hand and between the N.T. Docks and Kamut Lake complexes on the other. In the first instance the decisive factor might be listed as the diagnostic long points from Dismal — 1 and in the second it is the occurrence of side-notched points, lamellar blades, and crude burins in the Kamut Lake inventory. There is no sign of a well-developed microlithic industry at the Great Bear sites and therefore no apparent relationship that extends to the Dismal — 2 complex.

In the Simpson-Liard region, in the southwest corner of the Northwest Territories and northern British Columbia, several other complexes exhibit sporadic similarities to the Dismal-Kamut materials. The Pointed Mountain site, which is the best known of these (MacNeish 1954), contained both microlithic and large tool industries as in Dismal — 2 and Kamut Lake, but stratigraphy proved that both stemmed from a single level and thus, possibly, from a single occupation. The large tool industry at Pointed Mountain seems to share with Dismal — 1 contracting stemmed points (not unlike Fig. 4, No. 7), long side-notched points (not unlike Fig. 5, No. 1), ovoid blades, and possibly square-based blades (Fig. 4, No. 4 and 5, No. 2). Several scraper types are also similar, but wide distributions lessen their significance.

As for lamellar blades and the microlithic industry, I do not see much likeness between Pointed Mountain and the Dismal-Kamut materials. Pointed Mountain, for instance, is characterized by a proliferation of lamellar blades, consisting of many types both used and retouched and covering a wide variation in size. These attributes do not appear at all in the Dismal — 2 microlithic where there is no comparable emphasis on the using of microblades, but rather a much greater variety of specialized implement types, including points, knives, side blades, scrapers, burins, and gravers. There are angle burins like those in Pointed Mountain, but the two corner burins linked with the large flake components of Dismal — 2 and Kamut Lake show even closer resemblances (cf. Fig. 5, No. 17 and 7, No. 9).

Three other complexes in the Simpson-Liard region exhibit equally fractional ties with Dismal-Kamut. Sandy Lake, which antedates Pointed Mountain, according to MacNeish's tentative ordering (1954, p. 249), shares only a single type with Dismal — 1, the lanceolate point. Fisherman's Lake, which post-dates Pointed Mountain, shares nothing of diagnostic importance with the Dismal-Kamut inventories, only several generalized forms of scrapers. Spence River, the latest complex in the Simpson-Liard sequence, possesses several types that resemble Dismal — 1: corner-notched points,

plano-convex end scrapers, rectangular end scrapers, and large hoe-like sandstone scrapers (cf. Fig. 4, No. 22).

Summing up, the Simpson-Liard sequence seems to have had little effect on the Dismal-Kamut area. The few resemblances indicate that any relationship between the two areas was probably not direct but rather the result of a partial sharing of some broader and more ancient cultural base.

Beyond Great Slave Lake are three other complexes (MacNeish 1951) that appear to be related more closely with the Dismal-Kamut one, some 500 miles to the north-northwest of them. The earliest of these, Taltheilei, although identified on the basis of a very limited collection, agrees with Kamut Lake in one important type, the stemmed lanceolate point shown in Fig. 7 No. 3. The specimens are quite perfectly matched even in the use of the same material, a sedimentary rock, incidentally the chief ingredient in both complexes. Artillery Lake, which is believed to follow Taltheilei (MacNeish 1951, p. 38), matches very nearly with my Dismal — 1 grouping. All known Artillery Lake types are duplicated, including the lanceolate points with narrow, straight or convex bases, small plano-convex scrapers, large flake scrapers, choppers and ovoid blades. Still later in MacNeish's tentative scale, but possibly also overlapping in time with the above two complexes (MacNeish 1951, pp. 33, 38, 41) is the Lockhart River complex, which shares impressive traits with both Dismal — 1 and Kamut Lake. From Dismal — 1 may be noted the corner-notched points and possibly round-based points, large flake scrapers and knives, ovoid blades and choppers, whereas from Kamut Lake there are primarily side-notched points and possibly pear-shaped end scrapers. Of further interest is the fact that none of these three complexes east of Great Slave Lake, as far as they are known, contain any evidence of microblades or a microlithic technology.

Relationships with the Western Arctic

The Engigstciak site on the Firth River, near the Yukon arctic coast (MacNeish 1956b), is potentially one of the most important keys to an interpretation of the prehistory of the Central and Eastern Arctic, not to mention areas further south. Its stratified sequence of nine occupations must represent many of, if not all the land-oriented cultures that diffused eastward along the coastal fringe of Alaska and a considerable number of traits from the Dismal-Kamut complexes can be traced through its pre-pottery levels.

The first and earliest of these, the British Mountain complex, is still only scantily known from a handful of artifacts, so attempts to relate other complexes to it would be utterly unsafe. However, the next stratum above it, the Flint Creek complex, has certain counterparts in the Dismal-Kamut area. General types, such as thick scrapers, thin side scrapers, crude choppers, large ovoid blades, small chipped disk choppers, and turtle-shaped end scrapers seem to equate in both areas, but more important likenesses are to be noted in lanceolate points, which MacNeish calls Angostura

(1956b, p. 96), and crude burins, as exemplified by Fig. 5, No. 17 and 7, No. 9.

Flint Creek is succeeded by the New Mountain complex and the microlithic industry of this level checks at many points with Dismal — 2. They have in common microblades, both large and small crescent side blades, lenticular side blades (cf. Fig. 6, No. 6), rectangular corner or angle burins (Fig. 6, No. 12), and burin spall artifacts. The types of points are difficult to compare because the Dismal — 2 specimens are fragmentary and do not show stems or other distinct forms of base. Some of the latter, however, may be double-pointed or round-based and thus equivalent to certain New Mountain types. Nevertheless, there is one major difference in the point types of these two complexes: those from Dismal — 2 have very finely serrated edges, whereas there is no mention of this attribute in the New Mountain points. Further correspondence between the two complexes seems to occur in triangular end scrapers (Fig. 6, No. 25) and turtle-back scrapers (cf. Fig. 6, No. 27).

From this locality the evidence of microliths leads unquestionably westward along the Alaskan coastal zone to the Anaktuvuk Pass sites and thence to Iyatayet and the Cape Denbigh complex. Imaigenik, in Anaktuvuk Pass, stands in immediate, close relationship with the Denbigh complex, as Irving has shown (1953, pp. 60-65), so we may proceed directly to the latter and its probable ancestral role in the development of the Dismal-Kamut cultures. Specifically, I am impressed by the following resemblances between Dismal — 2 and the Denbigh Flint complex. One of the basic traits in each, of course, is the microblade, and although no cores were found at Dismal Lake, the size range and general conformity of the lamellar blades from Dismal — 2 are virtually the same as in Denbigh. Not all the burin types in the Denbigh complex appear in Dismal — 2, but the angle burins do, particularly the types shown in Fig. 6, No. 10 and No. 12, and one must also note the concurrence of a single type in the Kamut Lake inventory, Fig. 7, No. 24. Burin spall artifacts, which Giddings has more recently discovered in the Denbigh complex (1956b), also have their counterparts in Dismal — 2. Diagonally flaked side blades are an important trait at Denbigh, but they appear to be somewhat less so at Dismal — 2. Nevertheless, at least two specimens, the one at the extreme left in Fig. 6, No. 6, and probably the second from the right, are close to some of the Denbigh forms.

In addition to such diagnostic traits, other most interesting concurrences can be seen. The specimens illustrated in Fig. 6, No. 2 are all tip fragments of end blades, although some of them could as well be basal portions of double-ended points. However, in terms of their dimensions, well-executed parallel flaking, and finely serrated edges, I judge them to be exactly the same as some of the end blades that Giddings shows (1951, Fig. 61-a: 5,6). The Denbigh complex also contains a micro-burin with a retouched, pointed end (1951, Fig. 61-b: 2) which is partially duplicated by a microgravel, without the burin, in Dismal — 2 (Fig. 6, No. 18; cf. also Fig. 6, No. 19). In the category of thin blades or scrapers, the Denbigh

specimen, Fig. 62:15, is remarkably like the fragment of a blade in Fig. 6, No. 9 (middle). Other end scrapers are of more generalized forms which have wide distributions, but the several varieties of triangular type in Dismal — 2 are quite comparable with Denbigh.

Of course, it cannot be claimed that anything approaching agreement characterizes the relationship between Dismal — 2 and Denbigh, but I think the list of similarities in diagnostic traits is important. Moreover, there is more than mere similarity of trait incidence: at least in one significant aspect there is like emphasis or proportion. In a recent analysis of North American flint sites Giddings stressed the fact that burins and spalls comprised about one-fourth of all the flints in the Cape Denbigh complex and that approximately one-sixth of the Sarqaq collections from west Greenland was also made up of burins and spalls (1956a, p. 265). Therefore, it is of more than passing interest to note that in this respect Dismal — 2 lies roughly midway between these two complexes. Its inventory is perhaps dangerously small for such analysis, but burins and burin spalls comprise one-fifth of the microlithic collection found there, or one-sixth of the total collection, including the large flake artifacts.

Up to this point, I have tried to trace some of the fundamental orientations of the Dismal-Kamut materials without attempting a minute examination of their every possible relationship. In fact, it would be unreasonable to do so, for arctic archaeology still has great gaps, and most of the cultural linkages that we can postulate must remain loose and tentative.

However, it appears that we now have considerable evidence for an eastward diffusion of microlithic technology from the Bering Sea region to the northern slopes of the Brooks Range and thence along the coastal zone into the Central Arctic. This spread is highlighted by a probable parent strain in the Denbigh complex and derivative manifestations at Anaktuvuk Pass, the New Mountain stratum at Firth River, and at Dismal — 2, although I do not suggest that these sites necessarily fit into a neat unilinear progression. As for the appearance of microblade cultures elsewhere in Alaska and Canada, a second lobe of diffusion may have spread inland up the Yukon drainage, leaving recognition points at the Campus site (Rainey 1939), Birch Lake (Skarland and Giddings 1948), Dixthada (Rainey 1939), and Kluane Lake (Johnson 1946). It is possible also that Pointed Mountain in the Liard drainage was affected by this spread. I have constantly stressed the Denbigh finds here, so it is wise to recall that Irving, in discussing variations in cores (1953), has cautioned that the Denbigh Flint complex may not have been the only medium through which such traits came to the New World.

One of the most difficult questions that continues to plague investigators concerns the relationship between the microblade, or microlithic, and large tool complexes. Irving has commented on the lack of "macrolithic" implements in his Anaktuvuk sites (1953, p. 73); elsewhere in many of the sites mentioned above are all sorts of mixtures of micro- and macrolithic features. Even the Denbigh complex, if I may continue to think of it

in the nature of a New World parent, has a curious blend of microblades, cores, and burins with fluted and other types of points that are strongly reminiscent of more ancient complexes farther south. MacNeish's work at Firth River (1956b) has clarified the temporal priority of the larger tools, at least on the arctic slopes, but the general conditions surrounding the merger of these different traditions are still obscure. They may stem together from some Mesolithic compound, as yet unrecognized, in Siberia, or as has been recently suggested (Krieger 1953), the merger may in part be explained by a northward backwash of ancient American culture that diffused with major game animals after the retreating glaciers.

The Dismal-Kamut cultures, I believe, derived in large measure from the west. The Dismal — 1 complex may be considered the earliest in the area, on the basis of its relationships with the Great Bear River complex, which has a C-14 date of *circa* 4600 B.P. (MacNeish 1956a, p. 59), and the second stratum at Engigstciak, the Flint Creek complex. Still farther west this strain may link with finds that have been recently made at a new site in Anaktuvuk Pass, and hence possibly with the interior of Alaska (John Campbell, personal communication).

Toward the east, the Dismal — 1 complex may have been an important component in the ancestry of Artillery Lake and Lockhart River. These complexes are less accurately dated, but it is known that they could not have occupied the country east of Great Slave Lake until after the retreat of the glacier.

I have already shown by cross-cultural references what I believe to have been the derivation of the Dismal — 2 microlithic complex and, as suggested by general comparisons with the strata at Firth River, it may be the latest of the three complexes delineated here. On the other hand, the various affiliations of the Kamut Lake complex are much more difficult to integrate and leave the preceding supposition in doubt. In the west Kamut Lake relates to the N.T. Docks complex, which has a C-14 date of *circa* 3500 B.P. (MacNeish 1956a, p. 69), and its small constituent of microliths is also stratigraphically late in the north. Yet at the same time it has certain affinities with complexes that are earlier than the above, i.e., Flint Creek in the west, and Pointed Mountain, Taltheilei, and Lockhart River, to the south and southeast. The feature of greatest interest about it is that Kamut Lake may have resulted from the contact of a plains or boreal tradition with a microlithic technology that was apparently adapted mainly to the tundra. In the final analysis, however, it remains a strange blend that cannot be deciphered totally from the internal evidence.

The problem of a southern origin for certain arctic traits has been increasingly emphasized in recent years. Hibben (1943), Thompson (1948), Skarland and Giddings (1948), Giddings (1951), Larsen (1951), Collins (1951), and MacNeish (1951, 1953), have all compared selected arctic finds with Folsom, Yuma, Plainview, and Angostura prototypes, and I could add a further link to this chain by citing the Scottsbluff point from Kamut Lake (Fig. 7, No. 3). At present the hypothesis of a northward diffusion of such

types from plains complexes into the Northwest Territories and Alaska is not implausible because the arctic finds, insofar as some of them are reliably dated, are several thousands of years younger than the manifestations farther south. But still one cannot rule out the possibility of an ultimate northern priority for these traits. The troublesome factors continue to be the relative paucity of archaeological data from the north and the tremendous areas in central and western Canada that have yet to be bridged. In the meantime, I believe the Arctic should not be propped too heavily on typologies that were developed primarily for the analysis of ancient complexes far to the south. Meager though our evidence often is, at least it continues to grow, and soon a major attempt at area typology ought to be profitable. On such a base it may then be possible to establish broad and accurate regional correlations.

Relationships with the Eastern Arctic

As might be expected, the major bonds between the Dismal-Kamut area and early cultures of the eastern arctic stem from the Dismal — 2 microlithic complex, for, as Collins has noted (1956), it is this variety of material that lends a strong unity to prehistoric arctic cultures in the New World and also serves to relate them with the Mesolithic cultures of Eurasia. In this respect, Dismal — 2 provides a substantial link across the great central arctic *terra incognita*, and it strongly supports certain concepts of east-west relationships which heretofore have been eminently logical but largely conjectural.

First of all, it is evident that Dismal — 2 represents something of the ancestry of the Knife River site in northern Manitoba (Giddings 1956a). The inventories of these two sites are alike in the presence of angle burins and burin spall artifacts, and the numerical proportions of these types are significantly close. Giddings does not state the Knife River proportion exactly, but by indirection he equates it with both the Denbigh Flint complex and the Sarqaq collections (1956a, p. 265). I have already indicated that with respect to these figures the Dismal — 2 complex falls approximately midway between the latter two. Knife River and Dismal — 2 also have in common the use of side blades, and their end blades appear to be much the same. If my Fig. 6, No. 3 is actually a tapered stem, the resemblance of the points in these two sites becomes even closer. Some end scrapers are also comparable, particularly the triangular and flaring-edge types (cf. Fig. 6, Nos. 25 and 26). Despite these important compatibilities, there is one key difference: the microblade and core are not represented in the Knife River collection, a negative factor which Giddings stresses in generically linking Knife River with Sarqaq (ibid.).

Possibly the oldest stage of eastern Eskimo culture is exemplified by the Independence complex which Knuth has identified in Pearyland (1954, 1956). The first of two palaeo-Eskimo phases, which Knuth distinguishes

there, has a C-14 date of *circa* 3800 B.P. and is called Independence I. In common with Dismal — 2 it has angle burins, burin spalls, microblades, and convex-edged end scrapers. Possible further analogies are to be noted in the end scrapers that have flaring or bulging tips, and also in a type of asymetric knife blade that has one straight edge or back and an opposite convex edge. Such likenesses, however, are quite generalized, and it seems rather that Independence I derived primarily from some cultural impulse that was not yet truly microlithic. Knuth himself comments on the relatively greater size, roughness, and more primitive execution of these artifacts in contrast to those of Sarqaq, Dorset Eskimo, Denbigh, etc. (1954, pp. 376-377). Independence II is dated *circa* 2830 B.P. and, as represented by the finds from Danmark Fjord, it resembles somewhat more closely the later expressions of Sarqaq, Dorset, and to some extent Dismal — 2. In common with the latter it has angle burins, burin spalls, tapered-stem points, double ended points, and side blades. On the whole, however, I doubt that Dismal — 2 can in any way be considered ancestral to either phase of the Independence culture, although they both seem to share some elements from a remote past.

Sarqaq, the palaeo-Eskimo culture from west Greenland (Meldgaard 1952), apparently stands in much closer relationship with Dismal — 2. The dominant point type at Sarqaq is a slender pointed-oval biface with serrated edges and this, I hazard, may equate with some of the fragments in my Fig. 6, No. 2. Also, if Fig. 6, No. 3 is a tapered stem it compares closely with another Sarqaq type of point. Other related types are small, slender side blades, chipped on one or both faces; angle burins, although the Dismal — 2 specimens do not exhibit traces of grinding as do those from Sarqaq; burin spall artifacts (Giddings 1956b, p. 236); and a triangular variety of snub-nosed end scraper. Of course, in addition to such likenesses there are discrepancies, and chief among these may be the lack of microblades at Sarqaq.

In the realm of Cape Dorset Eskimo culture there is considerably more evidence available for comparative purposes, but the T 1 site recently excavated by Collins on Southampton Island (1956, 1957) should be most apt. Because of the many typological differences which distinguish it from Dorset manifestations, Collins has identified T 1 as formative or proto-Dorset, and a C-14 date of 2632 ± 128 B.P. has been obtained from one part of the site (Collins, personal communication). Clearly, T 1 must lie close to ancestral, pre-Dorset culture, whatever that may have been, and any correlations that it may have with Dismal — 2 should be of considerable interest.

T 1 lithic material is predominantly gray chert with an important minor component of rock crystal and, on a much reduced scale, the same may be said for Dismal — 2. Other minor occurrences of rubbed slate, nephrite, and steatite vessels also characterize T 1 but do not appear at all in Dismal — 2, with the single exception of the fragmentary steatite pendant. There does not seem to be even a general resemblance between

the various types of end blades, for the T 1 bases are predominantly straight or slightly concave and none of this kind were found at Dismal — 2. However, the specimens in my Fig. 6, No. 1 are similar to some of the small T 1 points in that they have a bulbar surface which is only slightly modified at the edges and a triangular cross-section with a median dorsal ridge. Both T 1 and Dismal — 2 show wide use of microblades, both have angle burins, although the T 1 specimens seem relatively crude, and both produced burin spall artifacts. T 1 does not have small, thin side blades, but its common larger type is matched by a single specimen from Dismal — 2, a thin rectangular blade with an unmodified bulbar surface (Fig. 6, No. 8, left). These appear to be the only occurrences yet known of this type in the American Arctic (Collins 1956, p. 69). Finally, the small chisel or gouge fashioned on the end of a quartz crystal (Fig. 6, No. 21) is also reported from T 1 (Collins, personal communication).

That sums up the resemblances between the proto-Dorset of T 1 and the Central Arctic complex of Dismal — 2, but it is curious to see how some traits of the latter crop up elsewhere in Dorset culture. For instance, the small quartz chisel just mentioned is perfectly duplicated by a Dorset specimen from Abverdjar Island (Rowley 1940, p. 495) and by another from the west coast of Newfoundland (Harp 1952). Thin side blades, although they do not occur universally in Dorset sites, are also an associated trait of this culture. The same may be said for end scrapers with flaring edges (cf. Fig. 6, No. 26), burins, microblades, and polyhedral cores.

On the whole, it seems to me that the kinship between Dismal — 2 and proto-Dorset T 1 is not any closer than it is between Dismal — 2 and other Dorset components. Furthermore, it is odd that Dismal — 2 in some aspects more closely resembles the later Dorset stages, particularly that which is believed to be the latest, in Newfoundland. Admittedly, however, the degree of relationship rests less on a series of specific artifact types than it does on matters of technique, general fineness of workmanship, and the conspicuous delicacy and small size of the artifacts.

There is so much variety manifest in the widespread Dorset, proto-Dorset, and pre-Dorset cultures, and their forebears, that we cannot yet equate them in terms of current evidence. Giddings's recent formulation of a scheme for classifying microblade, burin, and side blade sites, etc. (1956, p. 266), may be a useful framework in the future, but, as he is the first to state, it proves little now. Nevertheless, I believe these eastern sites are drawn closer together by virtue of the fact that they all possess some affinities with a central arctic microlithic complex, insofar as that may be represented by Dismal — 2. However, the linkages reviewed here have never been all-embracing, so one can by no means postulate a unitary drift of one or more complexes toward the east. In part, such lack of conformity can be accounted for by incomplete inventories, but, far more significantly, it must be explainable by those selective processes of diffusion and population spread that serve to advance some traits and hold back others.

Another important aspect of this problem of east-west affiliation concerns ecology. Lantis (1954) has stressed the role that ecological studies should have in arctic archaeology, although some of her precepts are still beyond our powers of deduction. Unquestionably, one very good reason why it is difficult to relate these various enclaves of culture, aside from those mentioned above, is that they represent adaptations to differing environments. In the Eastern Arctic, for example, all known Dorset, proto-Dorset, and pre-Dorset sites are coastal in location, a fact which connotes a sea-oriented economy, yet almost every one also contains some evidence of land-based economy. This has no doubt been responsible for the general assumption that Dorset culture was more or less equally dependent upon both land and sea for its subsistence, mainly on such game as the seal, walrus, and caribou (cf. Birket-Smith 1951, p. 147).

To carry this thought further, Mathiassen noted that Button Point, on the southeast corner of Bylot Island, is still an important settlement in spring and early summer when there is good seal and whale hunting (1927, Pt. 1, p. 206), and the implication is that Dorset people once camped there at the same season and for the same reason. Whale hunting, however, was not a feature of Dorset culture (Wintemberg 1940, p. 320). Dorset sites that I have investigated in northwestern Newfoundland fit this same pattern of spring hunting (Harp 1950). Lethbridge suggested that the Cape Hardy Dorset site on the north shore of Devon Island was mainly a fall camping place where both caribou and seals were hunted (1939, p. 222). Another variation comes from Knuth who believes that Dorset camps in Pearyland were based primarily on land-hunting, " . . . in accordance with palaeo-Eskimo habits . . .", with musk ox as the chief game and caribou as a subsidiary item (1952, p. 29). The latest and most careful analysis of food economy is the picture that Collins gives for the proto-Dorset T 1 (1956, p. 65): almost 89 per cent of the food bone debris of this occupation derived from sea-mammals, and caribou accounted for less than 1 per cent.

Collins has also suggested that the T 1 people did not hunt caribou because, lacking dogs, they had no effective winter transportation (ibid.), but in the general evidence sketched above there is at least a hint of a dualistic economy, if not of seasonal nomadism. What sort of an ecological adaptation are we to look for, then, on the part of the ancestral diffusions into Dorset country?

The Knife River site yielded no evidence of such matters, yet it is situated inland at a place which is traditionally favoured by Chipewyans for fall and winter caribou hunting (Giddings 1956a, p. 258). The case of Dismal — 2 is similar. The site lacked evidence from which economic patterns might be inferred, but Dismal Lake both now and in the recent past has been a preferred area for the fishing and hunting activities of the Copper Eskimo during summer and fall (cf. Jenness 1922, p. 21, and Banfield 1951, Figs. 4, 5, and 6). Judging from the finds I made in the Dismal — 1 vicinity, perhaps it may also be assumed that musk ox was formerly an important game animal in this area.

Still farther west along the line of known microlithic complexes, the New Mountain level at Firth River shows a definite inland orientation. Caribou was the primary game, but bones of bison, elk, musk ox, and an extinct variety of mountain goat were found in profusion in this stratum (MacNeish 1956b, p. 99). Imaigenik in the Anaktuvuk Pass area, although much farther inland, is also situated in a tundra zone where big land game, especially caribou, abounds. As for the Cape Denbigh site, its subsistence orientation may still be debatable, but I favour Collins's interpretation that it was a coastal location when first occupied and that the people of the Denbigh Flint complex hunted both land and sea-mammals (Collins 1954a, pp. 102-3).

Essentially, then, Birket-Smith's statement concerning a dual subsistence economy for Dorset society in the Eastern Arctic has possibilities of application among some of the probable antecedent cultures of the Western Arctic. The difference is that, whereas Dorset, proto-Dorset, and pre-Dorset sites in the east are primarily sea-oriented, at least in terms of their locations, several of the key sites in the Central and Western Arctic were clearly land-oriented. However, I do not think it unreasonable to conjecture that the latter were but an inland aspect of a generalized cultural adaptation that also was basically fitted for exploitation of littoral resources (cf. Kroeber 1939, pp. 22-26). For example, if one may draw analogies between prehistoric and recent times, the Anaktuvuk Pass occupations in this group were farthest from the sea, being approximately 150 miles inland from the present coastline, but this distance appears not to have daunted recent Eskimo in their quest for a richer food supply (Collins 1954b, p. 302). Furthermore, Dismal — 2 is about 60 miles inland from Coronation Gulf, but the Copper Eskimo, until the recent burgeoning of trade with white men, regularly visited the surrounding country in their annual nomadic rounds. The Engigstciak site on the Firth River is a mere 16 miles from the present coast, and in its New Mountain stratum the existence of a triangular blade that is comparable with possible harpoon points in the Denbigh complex may be a slight but positive indication of the littoral aspect of a dual economy.

If the general microlithic tradition which characterizes these particular occupations was indeed adaptable, with certain modifications, to subsistence pursuits both on sea coasts and inland, then we might expect to find emphasized in any given locality that aspect of it that most closely concerned the nearby food supply, whether interior or coastal. As a hypothetical extension of this view, perhaps somewhere north of Dismal — 2 may be microlithic sites on ancient strand lines still to be discovered, yet I do not believe they would be an absolute prerequisite to the diffusion of that tradition across the Arctic. In the region of the Barren Grounds, for instance, there might have been prolonged stress on land hunting and a corresponding diminution of coastal life, depending on the crucial factor of which afforded in any given period the easier life. Again, in the region of northern Hudson Bay with its wealth of sea-mammals there may have

come a recrudescence of sea-hunting techniques from the old cultural base. These matters must be intimately related to post-glacial climatic shifts, but aside from the possibility of making futilely broad generalizations about the Altithermal and ensuing Medithermal periods and their effects on early Eskimo ecology, I see no positive help from this quarter at present.

At any rate, the continuum from which the late eastern Dorset manifestations developed was a long and exceedingly complicated one. I have perhaps tended to over-estimate the ancestral role of microlithic technology in this continuum, but it seems to have been one of the major adaptations characteristic of the American Arctic. Moreover, it is traceable from Denbigh toward the east and at present we are able to perceive more clearly through this medium than any other definite relationships between east and west. However, a moment's thought indicates that a deeper explanation is required. Many of the Central and Western Arctic complexes mentioned here are mixtures constituted of arctic, boreal, and perhaps even plains traits, and the inclusion of some "macro" elements in early cultures of the Eastern Arctic suggests their diffusion in advance of later microlithic complexes. This was so in the west, as Engigstciak proves, and such cultures as Independence I, and to some extent the west Greenland palaeo-Eskimo Sarqaq and proto-Dorset T 1 testify to a like sequence in the east. I suspect that the essential ordering of Engigstciak's lower levels may have been perpetuated eastward across the Arctic, allowing, of course, for later specialized outgrowths in response to particular environmental conditions.

In closing, I should like to touch very briefly on one associated problem. In the northeastern sector of the continent, from Labrador southward as far as Maryland, the appearance of certain "Eskimo" traits in archaic Indian cultures has for long been an unresolved mystery. It was once thought that such anomalies were the result of early contact between the Beothuk Indian and Cape Dorset Eskimo in Labrador and Newfoundland, but I have explained elsewhere (1953) why I believe such diffusion could not have occurred there. In the light of the evidence reviewed in this paper I believe we must look to the geographical funnel of Alaska and the Northwest Territories for an explanation of such cultural parallels. The compounds of culture which occur there strongly attest to this area's having been a melting pot where fundamental Palaeolithic and Mesolithic impulses from the Old World met, diffused, and gave rise to special New World complexes.

There the circumpolar continuum takes on urgent meaning, but we simply do not as yet have sufficient evidence fully to understand the ebb and flow of diffusion either within that region, or passing outward from it. The need for more work in the "empty quarter" of the Arctic remains almost as great as ever.

Acknowledgements

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REVIEWS

ESKIMOKÜNSTLER, ERGEBNISSE EINER REISE IN ALASKA (ESKIMO ARTISTS, RESULTS OF A VOYAGE IN ALASKA)

By HANS HIMMELHEBER, *Kassel: Erich Röth-Verlag. 1938; 2nd edition, 1953. 9¾ × 6¾ inches, 44 plates, 19 text figures, sketch map, endpaper maps.*

DER GEFRORENE PFAD, MYTHEN, MÄRCHEN UND LEGENDEN DER ESKIMO (THE FROZEN PATH, MYTHS, FAIRY-TALES, AND LEGENDS OF THE ESKIMO)

By HANS HIMMELHEBER. *Kassel: Erich Röth-Verlag. 1951; 2nd edition, no date. 7¾ × 4¾ inches, 129 pages, frontispiece.*

It should be easier to obtain these two German publications, now that a second edition of each is available. Both, apparently in a series, "Das Gesicht der Völker", deal with the Nunivak Island-Lower Kuskokwim area of Alaska. Both show attractive bookmaking, to appeal to the general reader as well as the specialist. For a review of *Eskimokünstler* see *Am. Anthrop.* 44:123-4, 1942. For notes on *Der gefrorene Pfad* see *Anthrop. Paps. of the Univ. of Alaska* 2:109-11 and 168-70, 1953.

MARGARET LANTIS

GEOPHYSICS AND THE IGY

Proceedings of the Symposium at the Opening of the International Geophysical Year. Edited by H. ODISHAW and S. RUTTENBERG. *Geophysical Monograph No. 2, American Geophysical Union of the National Academy of Sciences — National Research Council. Publication No. 590, 1958. 10 × 7 inches; 210 pages, numerous illustrations, maps, graphs, and diagrams.*

In this volume is assembled a group of thirty papers covering many topics in geophysics. The papers were presented at a special symposium in June 1957 just before the IGY began. Some projects had been initiated before the IGY formally got under way, and as a result a few of the papers here presented contain early results of the IGY. The value of the volume is increased by this feature and also because many of the papers present the general status of the different geophysical disciplines at the opening of the IGY.

The papers fall into three groups: upper atmospheric physics, the lower atmosphere and the earth, and the polar regions. In the first group there are ten papers of a scientific survey type and four descriptions of instrumentation. These papers deal with solar-terrestrial relationships, probing of the ionosphere, whistlers and very low frequency emissions, the night airglow, and many other topics of research in upper atmospheric physics. There are some highly interesting papers on the rocket program, the rocket as a research vehicle, and scientific instrumentation of the satellites.

The second group contains ten papers on the lower atmosphere and the earth. These are survey articles, often with an outline of the proposed IGY work. Here are found discussions of the heat and water budget of the earth, synoptic meteorology, special meteorological studies, polar ice and snow studies, glaciology, oceanography, seismology and gravity.

The last group presents two articles dealing with the U.S. antarctic and arctic programs.

The book is of great general and historical interest and it belongs on the bookshelf in front of the long series of geophysical publications that will shortly begin to appear as a result of the tremendous undertaking called the International Geophysical Year.

SVENN ORVIG

GREENLAND

Published by the Royal Danish Ministry for Foreign Affairs. *Published in Canada by The MacMillan Company of Canada, Limited. 8¾ × 5¾ inches. 180 pages; map, numerous illustrations; $3.00.*

The first edition of this pleasant little book on "the world's largest island" was published in 1952. The Danish Ministry of Foreign Affairs has recently issued a new edition, containing all the original material and in addition three new articles. The original book was well received and this new edition will without doubt help even more to make Greenland better known and understood.

Some of Denmark's best-known Greenland men have joined forces to describe in ten chapters the country and its geography, the people and its history, its culture and daily life. The description of Greenland industries and occupations, and a look into the future, help in visualizing this land as much more than arctic wastes, and the book is well suited to satisfy the demands of the interested reader who knows little about the world north of the tree-line.

Among the fine illustrations (the one of a so-called "flying boat" is almost of historical interest) one will find a number of valuable old book illustrations from the nineteenth century and some from the eighteenth.

SVENN ORVIG

INSTITUTE NEWS

Annual Meeting of the Board of Governors

The Annual Meeting of the Board of Governors was held at the Institute Headquarters in Montreal on December 5, 1958. The following were elected for 1959:

Officers of the Board: Chairman, Dr. John C. Reed, U.S. Geological Survey, Washington, D.C.; Vice-Chairman, Dr. C. S. Lord, Geological Survey of Canada, Ottawa, Ont.; Secretary, Dr. M. J. Dunbar, McGill University, Montreal, P.Q.; Treasurer, Commander D. C. Nutt, Dartmouth College, Hanover, N.H.

Governors elected by the Fellows of the Institute: Dr. Trevor Lloyd, Dartmouth College, Hanover, N.H.; Dr. A. E. Porsild, National Museum of Canada, Ottawa, Ont.; Dr. Ira L. Wiggins, Stanford University, Stanford, Calif.

Governors appointed by the Board: Dr. J. C. Reed, U.S. Geological Survey, Washington, D.C.; F. T. Davies, Defence Research Board, Ottawa, Ont.; Dr. D. C. Rose, National Research Council, Ottawa, Ont.; Dr. A. L. Washburn, Dartmouth College, Hanover, N.H.

Retiring Governors: Dr. Richard F. Flint, Mr. R. F. Legget, Dr. H. M. Raup; Dr. M. Westergaard (resigned).

The 1958 Institute library report

The past year has seen the Institute library grow both in size and use. During the first full year in its new location on the ground floor of the Institute's Montreal office, the library's easy accessibility and consolidated form have lead to a great increase in the circulation figures:

Circulation	*1957*	*1958*
Books out	621	1110
Reprints and pamphlets out	244	366
Periodicals out	266	506
Inter-library loans lent	135	77
Total	1266	2059

This represents an increase of 63 per cent over 1957. The facilities of the library are becoming better known, not only to the members of the Arctic Institute but also to large business concerns who call upon us for bibliographical information, as well as for borrowing material.

We have added 672 volumes and pamphlets to the working collection of the library, an increase of 87 over last year. For the first time a count has been

kept of the serial material received. The library regularly acquires about 300 serial publications, which amounted to 1,278 separate items in 1958.

Among the accessions of the year are many Russian publications. A great wealth of material is being published on the arctic and tundra regions of the U.S.S.R. We are endeavouring to acquire as much of this material as possible, and have made a good start by arranging with several institutes in the U.S.S.R. the exchange of some of their publications for our quarterly journal *Arctic*.

The library holdings are being listed in the *Union Catalogue of the National Library;* our serial holdings are listed in the *New serials titles* of the Library of Congress and also in the second edition of the *Union list of scientific serials in Canadian libraries*. As we have several titles not held by other libraries, their value increases when their location is known, and they are more widely available for use.

Members of the Arctic Institute are encouraged to make use of their library. Those resident in Montreal are welcome to come in any time to browse and borrow. Those who live elsewhere are invited to borrow our books through an inter-library loan arrangement with their local library.

Complimentary copies of the following serial publications have been gratefully received during the past year:

Alaska Resource Development Board, Juneau, Biennial Report.
Alaska Resource Development Board, Juneau, Financial Data Regarding the Incorporated Towns and Cities.
Alaska University, Biological Papers.
Alaska University, Agricultural Experiment Station, Circulars.
Alaska University, Agricultural Experiment Station, Progress Report.
Antarctic Record — Reports of the Japanese Antarctic Research Expedition, 1956-57.
Augsburg, Institut für Menschen- und Menschheitskunde, Abhandlungen und Aufsätze.
British Glaciological Society, Glaciological Research Sub-Committee, Technical Notes.
Building Research in Canada.
Canada. Defence Research Board, Translations.
Canada. Defence Research Northern Laboratory, Technical Memorandum.
Canada. Department of Mines and Technical Surveys, Geographical Branch, Bibliographical Series.
Canada. Department of Transport, Navigation Conditions on the Hudson Bay Route, Annual Report.
Canada. Department of Northern Affairs and National Resources, Annual Report.
Canada. National Museum, Bulletin.
Canada. National Research Council, Associate Committee on Soil and Snow Mechanics, Technical Memorandum.
Canada. Northern Canada Power Commission, Annual Report.
Canadian Geophysical Bulletin.
C.I.L Oval.
Falkland Islands and Dependencies, Meteorological Service, Annual Meteorological Tables.
Falkland Islands Dependencies Survey, Scientific Reports.
Farthest North Collegian.
Geophysics — Meteorology (Helsinki).
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International Commission for the Northwest Atlantic Fisheries, Annual Proceedings.
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I.G.U. Newsletter.
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McGill Sub-Arctic Research Papers.
Münchener Geografische Hefte.
National Bank of Iceland, Reykjavik, Statistical Bulletin.
Northern Affairs Bulletin.
Royal Canadian Mounted Police, Reports.
Sapporo, Japan, Hokkaido Imperial University, Faculty of Science, Journal.
SCAN: a Monthly Bulletin.
Screenings from the Soil Research Laboratory.

Service de biogéographie, Bulletin.
Sociedad geográfica de Colombia, Boletín.
Sociedad geográfica de Lima, Boletín.
Soviet News Bulletin.
U.S.S.R. Illustrated News.
Wildlife Management Bulletin.
Yukon Territory, Ordinances.

NORA CORLEY, B.A., B.L.S.,
Librarian.

Gifts to the library

The Institute library acknowledges with thanks gifts of books, reprints, and maps from the following persons and organizations:

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C. R. Harington
C. I. Jackson
T. Lloyd
Irene Lubinsky
W. G. Mattox, Jr.
S. Orvig
J. M. Powell
F. Salomonsen
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Canada Defence Research Board
Canada National Research Council, Division of Mechanical Engineering
National Research Council, Washington, D.C.

NORTHERN NEWS

Geomorphological work along the north shore of Great Bear Lake

With the help of a grant from the Banting Fund provided through the Arctic Institute the writer, assisted by Pamela Russel, both from McGill University, visited the area north of Dease Arm, Great Bear Lake, N.W.T., from late June to late August 1958 to study the glacial morphology.

The party flew in from Yellowknife by charter plane, establishing caches en route. Work had to be started farther south than originally planned because of late break-up on the northern lakes, and a landing was made about 40 miles north of Great Bear Lake, where a river cuts through a large esker at an altitude of about 835 feet above lake level. This esker is the largest the writer has found during air photo interpretation of the Barren Grounds. It has small branches, which join it at almost right angles from the north and south. The top of the esker stands 160 feet above the drift-covered plain to the south and has a caved-in top approximately half a mile wide.

The 80-mile descent to Great Bear Lake was made in a folding kayak down the river and short land traverses were made on the drift plain en route. Trees appear in the river valley approximately 20 miles north of the lake. The river is a youthful one, full of rapids, and passes in its lower course through a series of long lakes, which lie parallel to north-dipping sandstone ridges. The short links between these lakes consist of rapids and waterfalls. The greatest difference between any two lake levels was perhaps 160 feet.

Raised beaches are abundant along the lake shore. Their heights were measured in some cases by aneroid, in others by levelling. The most easterly beaches examined were 16 miles up the Dease River, in a bay of proto-Great Bear Lake, and measurements were continued to a bay 40 miles west of Haldane River. The dip of the beaches toward the west amounts to 115 feet over a distance of 100 miles. The highest beach is about 290 feet above the lake in the east and 175 feet in the west. To complete the picture further investigations will be necessary farther to the west, and north of the lake.

The remains of Fort Confidence and houses built along the Dease River by Hodgson, Hornby, Father Rouvier, and by the party led by George M. Douglas in 1911 were also visited.

ANNEMARIE KRÖGER

Lichenometrical studies in West Greenland

The great climatic differences between the humid outer coast and the arid margin of the inland-ice express themselves clearly in the vegetation of the Söndre Strömfjord area. Along this climatic gradient the changes in the vegetation of lichens and higher plants have been studied with the help of the previous work of T. W. Böcher, M. S. Christiansen, and K. Holmen in this region. The most rapid changes from oceanic to continental elements in the flora occur in the outer third of the fiord, they vary according to the terrain, taking place generally at sea-level nearer the coast and at higher altitudes farther inland. To obtain criteria of the micro- and macro-climate, as expressed in the growth of lichens, crustaceous species have been photographed at marked stations between Sukkertoppen and Söndre Strömfjord Air Base. The British Cambridge University West Greenland Expedition and the Franco-Suisse Greenland Expedition under René Dittert have taken additional photographs in their areas of investigation. The photographs with exact indications of their localities have been deposited at the Montreal Office of the Arctic Institute; they should be repeated in about 10 years.

The plant succession on the moraine systems of 15 glacier forelands has been studied. Diameters of rock lichens and cushion plants and growth rings of *Salix glauca* stems have been used to date the last glacier advances. Old grave stones in Sukkertoppen gave a preliminary dated base to find the speed of the growth of the lichens. This allows a reasonably accurate dating of moraines in the vicinity. Morphological characteristics of moraines, observed recession of glaciers since the air survey (carried out mainly from 1941 to 1943), and growth rings of woody plants permit a comparison with glaciers farther inland. All methods indicate a large advance around 1740 or 1780 or both of all glaciers visited; at larger ice bodies these moraines are the oldest Recent ones. Within these systems one finds generally traces of a re-advance culminating around 1880 and smaller moraines with greater local variation. Smaller glaciers show sometimes older, but still Recent moraines in front of the massive boulder ridges from the eighteenth century. By extrapolating the growth rate of lichens it is found that the older moraines have been formed around 1600. Still older moraines bear a lichen cover in balanced condition and do not differ in this respect from the region outside the moraines. The lichen thalli have reached maximum diameters and although these are smaller than in the Alps, their growth is so slow that in the continental region the largest thalli of *Rhizocarpon* spp. may well be 4,500 years old. Their maximum age in the coastal region lies between 1,500 and 2,500 years. Microclimatic differences due to variations of the duration of the snow cover and the exposure increase their effects on epipetric vegetation considerably in the continental part. The moraines with a minimum age of 1,500 to 4,500 years — as far as lichenometry can be applied — may be in part late glacial, but at least in one case a correlation with a low shore-line could be made, which suggests a re-advance after the thermal optimum. In contrast to the large amount of morainic material deposited during the Recent advance period from 1600 to 1880 older moraines are scarce and often small. Separate detailed reports on the glaciological and lichenometrical results and on the botanical results will be made later.

The field work was carried out by the writer and was made possible mainly through a grant from the Banting Fund, provided through the Arctic Institute of North America and the extremely kind collaboration of the Danish authorities.

R. E. Beschel

Geomorphological investigations in the Kaumajet Mountains and Okak Bay (North River) region of Labrador

During the summer season of 1958 the writer, assisted by his wife, worked in the Kaumajet Mountains and Okak Bay area of northeast Labrador. The party was taken by air to Hopedale and thence

by coastal steamer to Nain. A fishing boat and crew from Nain transported the party to a narrow isthmus separating Kai-Kai Inlet and Neisser Inlet in the Kaumajet Mountains 120 miles northwest of Nain where a base camp was established on July 9. From there investigations were carried out on the inland block of the Kaumajet Mountains and on the lower land to the west as far as the Resolution Bay branch of Napartok Fiord. This camp was also used as a supply point for work on the two island blocks to the east, which together with the inland block constitute the Kaumajet Mountains.

An 18-foot canoe powered by a 5½-hp. Johnson outboard motor was used for travel around the island and mainland coasts. Secondary base camps were established at points on the coast from where the inland areas were accessible. Auxiliary camps were established inland and investigations carried out from them. In this manner an extensive reconnaissance of the area was possible.

Fine weather during the first 9 days made intensive work possible in the inland area, particularly on the inland block of the mountains. Exploration of the islands was, however, hampered by 19 days of continuous fog.

Attention was concentrated on the glacio-geomorphic features of the area. Numerous distinctive glacial erratics show that mass movement of the ice in the area was from west to east and that at its maximum the ice overrode all the summits[1] (highest Mt. Brave, 4,500 feet). The direction of the ice movement was strongly influenced by the topography of the pre-glacial mountain blocks and smoothed rock forms indicate channelling of the ice from southwest to northeast through Kai-Kai Inlet and Mugford Tickle. An examination of raised deltas and fragmentary shore-lines of the small lakes in the centre of the middle Kaumajet block suggests that the final stage of deglaciation was that of downwasting, exposing the valley cols before the valley mouths. Fresh striae were found at 2,400 feet on the undulating summit surface of the inland mountains in a place considerably higher than the upper limit of the later cirque glaciation. Consideration of these and of kame terrace forms worked into frost-shattered mountain top detritus on both the inland mountains and Cod Island suggests that the base of the last major glaciation, tentatively correlated with the final stage of glaciation recognized in the Torngat Mountains[2], certainly covered two-thirds of the Kaumajet Mountains area and possibly overrode it all.

Final glacial activity in the area was confined to the well-developed cirques and the mountain valleys. The positions of terminal moraines indicate that the small glaciers of this period did not extend into the main troughs. The remarkable freshness of the material found in these moraines suggests that the disappearance of the cirque glaciers took place in comparatively recent historical time.

On August 15 the party moved by fishing boat to Okak Bay, which is approximately 50 miles southwest of the Kaumajet Mountains. A base camp was established at the head of the bay on a small point of land alongside the tents of two Eskimo families who were engaged in the summer occupation of trout fishing. From this camp investigations were carried out inland.

Travel was by canoe up the major rivers, additional camps were established when the chosen areas were reached and further examination was carried out on foot between auxiliary camps within these areas. The first area to be examined was to the north and east of Umiakovik Lake, accessible from Umiakovik Brook, a tributary of North River. The second was the high land to the north of the northern tributary of North River. The third was the Umiakoviarusek River and Umiakoviarusek Lake area accessible from Ikinet Brook.

The evidence collected may be fitted into a tentative chronology of the final

[1]Wheeler 2nd., E. P. 1958. Pleistocene glaciation in northern Labrador. Geol. Soc. Am. Bull. 69:343-4.

[2]Ives, J. D. 1959. Glacial geomorphology of the Torngat Mountains, northern Labrador. Geog. Bull. No. 12.

emergence of the whole area from the last ice-sheet. The wide-spread cover of ground moraine, the many striae, glacial flutings, chatter marks, and perched boulders, which are particularly numerous on the surface of the dissected upland, indicate that the whole area was covered with ice at the maximum of the late Pleistocene glaciation and that the flow of ice was from west to east. Late stages in the deglaciation were characterized by downwasting, exposing the higher surfaces first, and by the ice that filled the troughs damming extensive lakes in hanging valleys and in depressions in the upland surface. Final ice activity was confined to the troughs where well-developed push moraines indicate late re-advances of the ice-front before its final disappearance.

Examination of the mass of evidence found in the Kaumajet Mountains and the Okak Bay area suggests that the whole region was covered with ice, which originated in the west and flowed to the east, in the final stage of glaciation of the area, which may be tentatively correlated with the Wisconsin of central North America.

The party left Okak Bay on September 21 and returned to the McGill Subarctic Research Laboratory at Knob Lake via Nain and Hopedale. This work was made possible by a grant from the Banting Fund provided through the Arctic Institute of North America. The sincere thanks of the party are also due to the Johnson Outboard Motor Company who made the outboard motor available for use during the summer and to many friends on the coast for their invaluable help and encouragement. The writer wishes to acknowledge the invaluable help and advice given by Dr. E. P. Wheeler. The work is being written up in full at McGill University during the present winter.

R. F. TOMLINSON

ELECTION OF FELLOWS

At the Annual Meeting of the Arctic Institute held in Montreal on December 5, 1958 the following were elected Fellows of the Institute:

Sq. Leader Scott Alexander, Downsview, Ont.

Dr. T. E. Armstrong, Scott Polar Research Institute, Cambridge, England.

Dr. C. A. Barnes, University of Washington, Seattle, Wash.

Dr. F. Graham Cooch, Canadian Wildlife Service, Winnipeg, Man.

Mr. Patrick McTaggart Cowan, Toronto, Ont.

Dr. Francis Fay, U.S. Public Health Laboratory, Anchorage, Alaska.

Dr. Dean Fisher, Fisheries Research Board of Canada, Montreal, P.Q.

Dr. George Llano, National Academy of Science, Washington, D.C.

Mr. Alan Loughrey, Canadian Wildlife Service, Ottawa, Ont.

Dr. Waldo K. Lyon, Naval Electronics Laboratory, San Diego, Calif.

Dr. Robert A. McKennon, Dartmouth College, Hanover, N.H.

Dr. Siemon W. Muller, Stanford University, Stanford, Calif.

Dr. Donald S. Rawson, University of Saskatchewan, Saskatoon, Sask.

Dr. Kirk Stone, University of Wisconsin, Madison, Wisc.

Rear Adm. (ret.) Charles W. Thomas, University of Washington, Seattle, Wash.

GEOGRAPHICAL NAMES IN THE CANADIAN NORTH

The Canadian Board on Geographical Names has adopted the following names and name changes for official use in the Northwest Territories and Yukon Territory. For convenience of reference the names are listed according to the maps on which they appear. The latitudes and longitudes given are approximate only.

Chart 5603, Cape Norton Shaw to Cape M'Clintock
(Adopted April 3, 1958)

Neptune Rock	78°40′N.	74°3′W.	

Pelly River, 105 NW. and 105 NE.
(Adopted April 3, 1958)

Shelf Lake	62°08′N.	128°10′W.	
Upper Hyland Lake	62°03′	128°52′	
Zenchuk Lake	62°05′	128°12′	
Little Hyland River	62°00′	128°33′	
Bologna Creek	62°20′	128°14′	
Red Willow Mountain	62°17′	130°27′	
Little Owls Mountain	62°05′	129°18′	
Bologna Ridge	62°18′	128°25′	
Mount Mulhulland	62°12′	128°01′	
Tadru Mountain	62°25′	135°52′	
Mayo (town)	63°36′	135°54′	not Mayo Landing (post office)
Little Nahanni River	62°29′	128°38′	not Guy River
Zenchuk Creek	62°07′	128°28′	not Duncan Creek
Kuskula Creek	62°02′	128°20′	not Danny Creek
Chechera Mountain	62°16′	131°58′	not Rotten Mountain
Mount Pike	62°10′	129°40′	not Tasnei Mountain
Mount Appler	62°17′	128°00′	not Mount Vangie nor Glacier Mountain
Altered application			
Clearwater Creek	63°03′	132°18′	
Name confirmation			
Hess River	63°33′	133°58′	not South Fork (river)

Northwest Shakwak Valley, Area of 115 F, G, K
(Adopted April 3, 1958)

Bull Creek	61°36′N.	140°27′W.	
McLennan Creek	61°51′	140°53′	
Count Creek	61°32′	140°33′	
Lignite Creek	61°51′	141°00′	
Name changes			
Brooke Creek	61°37′	140°40′	not Boulder Creek
Generc River	61°50′	140°40′	not Klutlan River
Frying Pan Creek	61°59′	140°55′	not Pan Creek
Altered applications			
Koidern River			(headwaters only)
Edith Creek	61°44′	140°10′	

Banks Islands, 98 SW. and 98 SE.
(Adopted April 3, 1958)

Gettis Lake	73°32′N.	120°25′W.	

Chart 5348, Hopes Advance Bay and Approaches
(Adopted April 3, 1958)

Gable Point	59°22′N.	69°26′W.	
Range Point	59°20′	69°34′	
Merganser Point	59°21′	69°41′	
Breakwater Point	59°21′	69°38′	
Tryon Bluff	59°16′	69°28′	
Apex Hill	59°19′	69°40′	
Ford River	59°19′	69°45′	
Cone Island	59°13′	69°10′	
Buttress Island	59°36′	69°25′	
Sandpiper Islet	59°37′	69°14′	

Wide World Photos

OBITUARY

Sir Hubert Wilkins (1888-1958)

Sir Hubert Wilkins died on November 30, 1958, in New York. He had been a Fellow of the Arctic Institute of North America since its foundation, and in 1947 was appointed Assistant to the Chairman of the Board of Governors. The following notice was written by his friend Col. Bernt Balchen in Chappaqua, New York.

The passing of Sir Hubert Wilkins on November 30 means the loss of one of the most colourful figures of polar aviation and exploration.

Sir Hubert was born in South Australia on October 31, 1888. He received his education as a mining engineer in Adelaide, and in his younger years worked as electrical engineer, meteorologist, and movie photographer. It was this last vocation that started him on his career of adventure and exploration.

In 1912-13 he followed the Turkish Army as a movie photographer in the Balkan War. He was second in command of the Canadian Arctic Expedition 1913-18. He then joined the Royal Australian Flying Corps, learned to fly in 1917, and saw war service as a photographer and in the intelligence services. He was mentioned twice in dispatches and was awarded the Military Cross with Bar.

After the war he served as navigator on one of the England-Australia flights in 1919, was second in command of the British Imperial Antarctic Expedition 1919-20, naturalist with the Shackleton Antarctic Expedition 1921-22, leader of the Australian Islands Expedition 1922-25 and leader of the Detroit Arctic Expeditions 1925-28. During these expeditions some very important pioneering flights were made in the Arctic, the most outstanding of which was the flight from Point Barrow, Alaska, to Green Harbour, Spitzbergen, April 15 to 21, 1928, which Wilkins and his pilot, Carl Ben Eielson, undertook in a single-engined Lockheed Vega. On this flight they crossed large areas of the Arctic Ocean in which other explorers had claimed to have seen land, but where Wilkins and Eielson found none. For this flight he was knighted on June 14, 1928.

Sir Hubert then became leader of the Wilkins-Hearst Antarctic Expedition 1928-30 during which he discovered more than 500 miles of new coastline in the Graham Land sector. In 1931 he was leader of the Ellsworth Nautilus Submarine Expedition to the Arctic, and from 1932 to 1939 manager of the Ellsworth Antarctic Expeditions. The highlight of these was the trans-Antarctic flight from the Weddell Sea to Little America by Lincoln Ellsworth and Herbert Hollick-Kenyon in November 1935.

Sir Hubert headed the search expedition for the lost Soviet flyer Levanevsky in 1937-38 and during the search covered about 170,000 sq. miles of the Arctic Ocean never previously seen. From 1942 he served as consultant to the U.S. Armed Forces on arctic problems.

During his many flights and travels in the Polar regions Sir Hubert acquired a great store of knowledge of these environments, that provided invaluable help for later expeditions. He was the recipient of numerous honours from all over the world and was recognized by the American Geographical Society and the Royal Geographical Society. He was the author of many books, and active as scientist and lecturer.

Sir Hubert was a man of the type that you always looked forward to meeting again. His memory will be cherished by those of us who had the privilege of being with him on polar expeditions and we shall always remember him as the finest companion one could wish for. He had courage and daring but was always even-tempered, kind and modest.

BERNT BALCHEN

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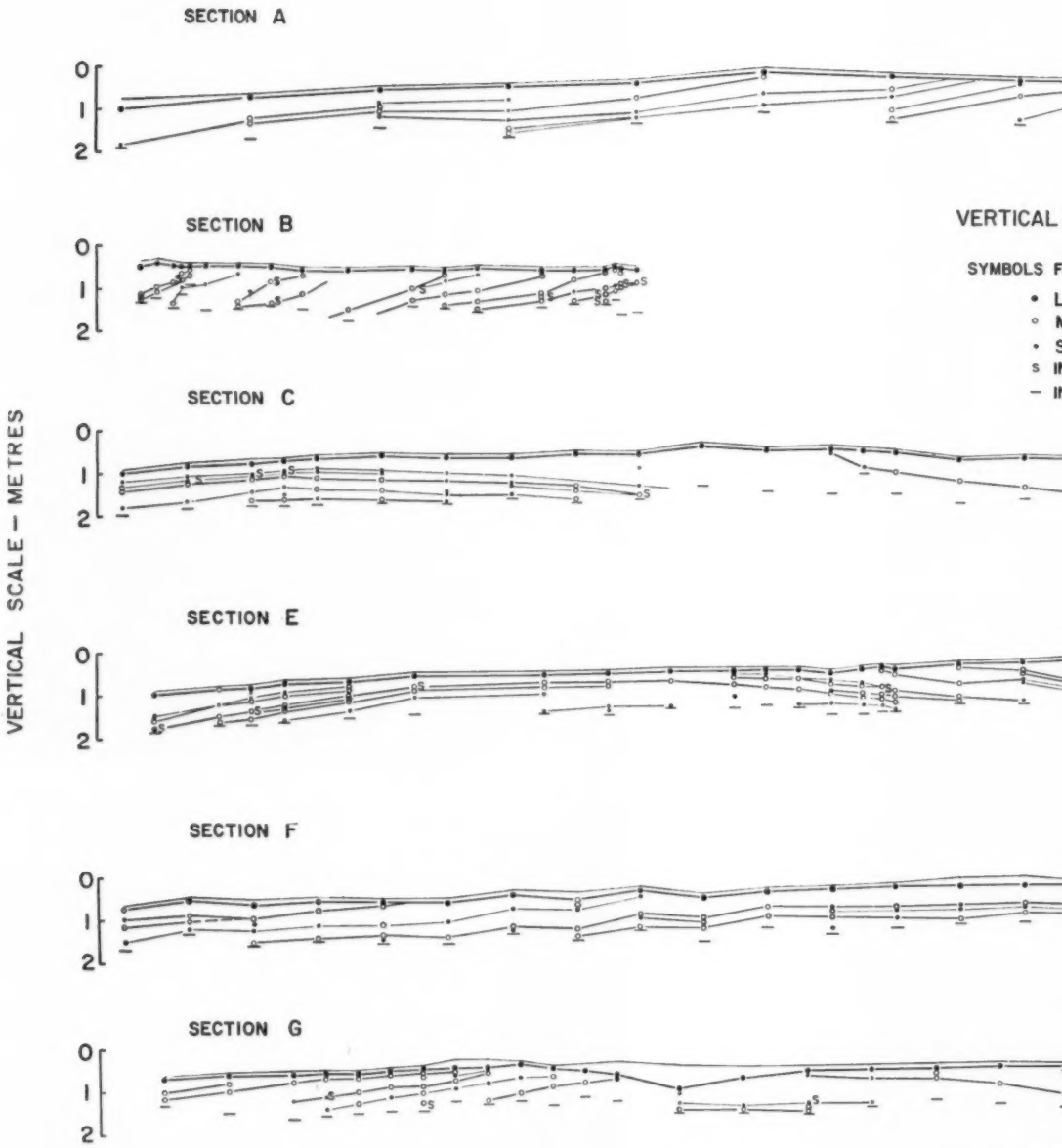
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VERTICAL SCALE – METRES
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Fig. 19. T-3

CAL EXAGGERATION 2:1

OLS FOR QUANTITY OF DIRT

- • LARGE
- ◦ MEDIUM
- · SMALL
- S INDICATES SCATTERING
- — INDICATES BOTTOM OF DRILL HOLE

HORIZONTAL SCALE — METRES

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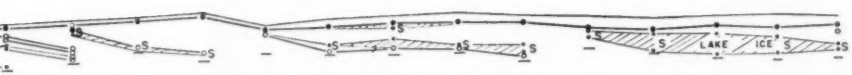

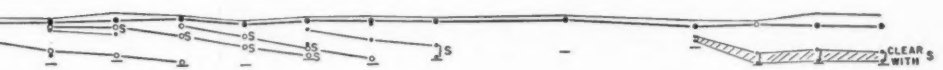

T-3 profiles based on shallow drilling.